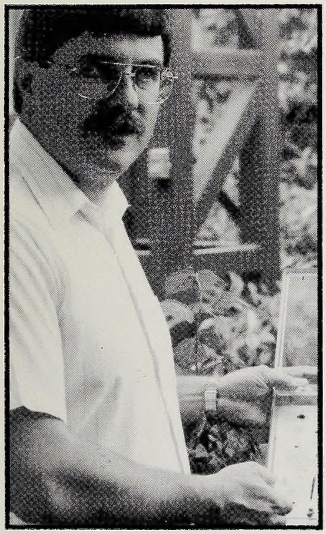
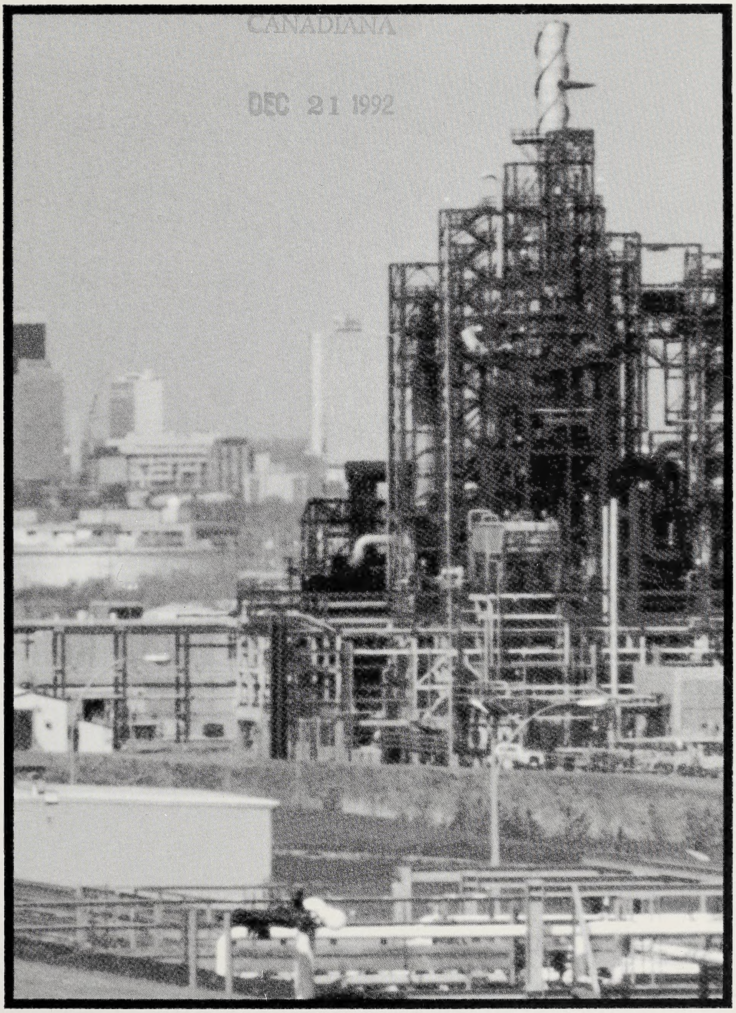
SCIENCE 9





Modules 1-6

Learning Facilitator's Manual

Distance Learning

Alberta
EDUCATION

Science 9

Modules 1 – 6

LEARNING FACILITATOR'S MANUAL

Distance Learning

Alberta
EDUCATION

Note

This Science 9 Learning Facilitator's Manual contains answers to teacher-assessed assignments and the final test; therefore, it should be kept secure by the teacher. Students should not have access to these assignments or the final test until they are assigned in a supervised situation. The answers should be stored securely by the teacher at all times.

Science 9
Learning Facilitator's Manual
Modules 1 - 6
Alberta Distance Learning Centre
ISBN No. 0-7741-0613-1

Teachers

Register with the Alberta Distance Learning Centre

The Alberta Distance Learning Centre is dedicated to upgrading and continually improving your learning facilitator's manual so that it accurately reflects any necessary revisions we have had to make in the student module booklets or the assignment booklets. The types of revisions that will be made are those that make the course more accurate, current, or more effective.

The ADLC will send you the latest enhancements and upgrades for your learning facilitator's manual if you return the following registration card to: Alberta Distance Learning Centre, Box 4000, Barrhead, Alberta, T0G 2P0, Attention: Design Department.

ADLC Learning Facilitator's Manual
Registration Card

First Name	Surname
School Name	School Phone Number
School Address	
City	Postal Code
Course Title	Approximate Date of Purchase

You can help ensure that distance learning courseware is of top quality by letting us know of areas that need to be adjusted. Call the Alberta Distance Learning Centre free of charge by using the RITE line and ask for the Editing Unit. Also, a teacher questionnaire has been included at the back of most learning facilitator's manuals. Please take a moment to fill this out.

We're looking forward to hearing from you!

Contents

Introduction

A survey of these course materials will confirm that this new learning package has been specially designed for many kinds of teachers working in a variety of situations.

Which Category Do You Fit?

- ❑ Small Schools Teacher
    - ❑ inexperienced
    - ❑ experienced, but in other subject areas
    - ❑ experienced in teaching junior high science, but wanting to try a different approach

- ❑ Distance Learning Teacher
    - ❑ travelling to schools within the jurisdiction
    - ❑ using facsimile and teleconferences to teach students within the area

- ❑ Larger Schools Teacher
    - ❑ inexperienced
    - ❑ experienced in teaching junior high science, but wanting to try a different approach

Because these materials have been created by experienced classroom teachers and distance learning specialists, they have many advantages for students and teachers regardless of their situations.

Advantages for Students

- incorporates a strong learner-centred philosophy
- promotes such qualities in the learner as autonomy, independence, and flexibility
- is developed through media which suit the needs and circumstances of the learner
- reflects the experiential background of Alberta students
- opens up opportunities by overcoming barriers that result from geographical location
- promotes individualized learning, allowing learners to work at their own pace

Advantages for Teachers

- allows teachers maximum teaching time and minimizes preparation time
- includes different routes through the materials to suit different learners
- incorporates a wide range of teaching strategies, in particular those using independent and individual learning
- delivers curriculum designed by education specialists that reflects the Alberta Education Program of Studies with an emphasis on Canadian content
- provides learning materials which are upwardly compatible with advanced educational technology

Does it sound like something you could use?

The student materials are not the only components designed for independent, guided instruction; so is this Learning Facilitator's Manual. It begins with an overview of the current Alberta Education Program of Studies for Science 9. This summary is included for inexperienced teachers or those teachers who have found themselves teaching Science 9 when their training is in other subject areas. This brief summary is not meant to replace the Alberta Education Program of Studies, but rather to help teachers confirm the highlights of the program.

Other parts of this introduction have also been included to help teachers become familiar with this new courseware and determine how they might want to use it in their classroom.

Beyond the introduction the guide itself contains answers, models, explanations, and other tips generated by the teachers who authored this course.

The courseware and LFM are the products of experienced classroom teachers and distance learning specialists. It is the hope of these teachers that their experience can be shared with those who want to take advantage of it.

Overview of the Program of Studies

The secondary science program is designed to promote scientific literacy. A person who is scientifically literate

- demonstrates a working knowledge and practical understanding of the sciences
- has the ability to evaluate scientific evidence
- understands the processes by which scientific knowledge is developed and can adapt those processes for personal use
- applies science concepts, theories, and processes as appropriate to the investigation of everyday problems
- understands the relationship of science and technology
- demonstrates awareness of how science and technology can function responsibly in a social context
- recognizes the limitations as well as the usefullness of science and technology in advancing human welfare
- demonstrates a continuing interest in science and technology.[1]

The junior high science program involves life science, earth science, and physical science for each of the junior high grades. The concepts are introduced through a broad range of experiences – including those based on first-hand experience.

The content is presented with three emphases to indicate the context. Each of these emphases has unique problem-solving skills associated with it:

(1) **Nature of Science** (S) – the process by which scientific knowledge is gathered. Associated with this are science inquiry skills of questioning, proposing ideas, designing experiments, gathering data, processing data, and interpreting data.

(2) **Science and Technology** (ST) – the application of science to the solution of practical problems. Involved with this are the technological problem-solving skills of understanding the problem, developing a plan, carrying out the plan, and evaluating.

(3) **Science Technology and Society** (STS) – the implication of science and technology with respect to the individual and society. Related to this are the decision-making skills of identifying the issue, identifying the alternatives, researching, reflecting and deciding, taking action, and evaluating.

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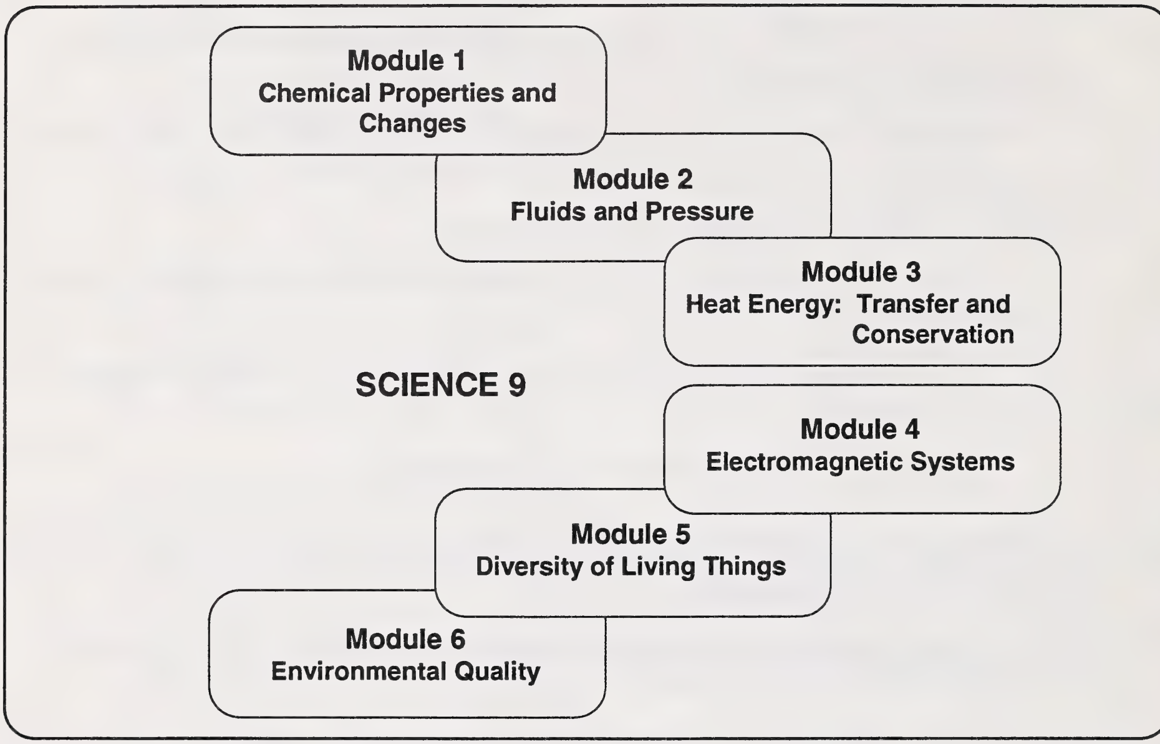
[1] Alberta Education, Curriculum Branch for the excerpt from Junior High Science Program of Studies Revised 1990 Edition. Reprinted by permission of Alberta Education.

The junior high science program is comprised of modules – six at each grade level. Each module focusses on a particular science topic using one of the listed emphases (S, ST, or STS) as a major emphasis. However, each module also supports learning with the other two emphases.

Overview of Science 9



The Grade 9 Science course consists of six modules each with a particular science topic and a major emphasis.

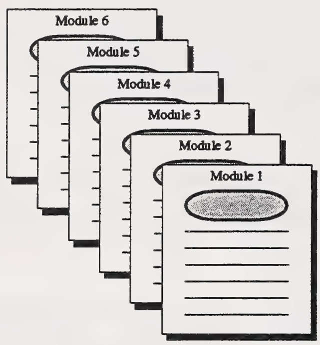
Module	Emphasis	Content
1. Chemical Properties and Changes	S	chemical and physical properties of common substances; chemical and physical changes; acids and bases; rates of reaction
2. Fluids and Pressure	ST	compressibility, viscosity, and density as properties of fluids; pressure of fluids; buoyancy; hydraulic systems and other fluid systems
3. Heat Energy: Transfer and Conservation	ST	concept of heat energy; heat transfer by conduction, convection, and radiation; technologies used to contain heat and to transfer heat; solar energy; energy conservation
4. Electromagnetic Systems	ST	production of electricity using electrochemical cells, thermocouples, and solar cells; electromagnetic effects as in motors and generators; measurement of electricity; basic circuitry and switching; electrical resistance; desigh of simple circuits in devices that use electricity; safety
5. Diversity of Living Things	S	similarities and differences in structural and behavioral adaptations of living things; artificial selection; natural selection and its role in evolution; classification of living things
6. Environmental Quality	STS	concept of environmental quality; methods of monitoring the quality of the environment; effects of human activities on the environment; pollution and waste disposal; role of decision making in protecting the environment

Structure of the Learning Package

Basic Design

This new learning package involves many other components in addition to the Learning Facilitator's Manual.

Modules



The print components involve many booklets called modules. These modules contain guided activities that instruct students in a relevant, realistic setting.

The modules have been specially designed to promote such qualities in the learner as autonomy, independence, and flexibility. Writers have incorporated such teaching strategies as working from the concrete to the abstract, linking the old to the new, getting students actively involved, and using advance, intermediate, and post organizers. Many other techniques enable learners to learn on their own for at least some of the time.

Contents
Overview Evaluation
Section 1 Activity 1 Activity 2 etc.
Section 2 Activity 1 Activity 2 etc.
Section 3 Activity 1 Activity 2 etc.
Section 4 Activity 1 Activity 2 etc.
Module Summary

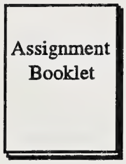
The structure of the module booklets follows a systematic design. Each module begins with a detailed table of contents which shows the students all the main steps. It acts as an organizer for students. The overview introduces the module topic or theme. A graphic representation has been included to help visual learners and poor readers. The introduction also states the weightings of each assignment.

The body of the module is made up of two or more closely related sections. Each section contains student activities that develop skills and knowledge centred around a theme.

The activities may involve print, audio, and video formats. At times the student and the learning facilitator are allowed to choose the activity that best suits the student's needs and interests. Activities such as the Extra Help and Enrichment are alternate pathways. This flexibility caters to each student's personal situation.

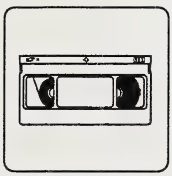
The summary focuses on the skills and strategies that the student has learned.

Assignment Booklet



Accompanying each module is an assignment booklet. The activities in these booklets can be used for formative and for summative assessments. The students should complete these assignment booklets when they have thoroughly reviewed the module materials. The assignment booklets have been designed for classroom use, for faxing, or for mailing. **If the booklets are not being mailed, you should remove the outside cover.**

Media



VIDEOCASSETTE

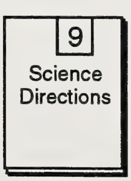
The package also includes references to media. Pathways have been developed so students can use a variety of media to achieve the objective. These different routes have been included to suit different learners. Wherever videos have been included, a print pathway is also available. This way, if the media resource isn't available or desired, a student can follow the print pathway and still successfully achieve the objective.

COURSE
AUDIOCASSETTE
(providing general
teacher guidance)

A special audiocassette features a teacher guiding the student through the course. The appearance of the teacher icon reminds students that there is this additional help available.

If the students are working individually, you may find this cassette a valuable asset. If you are working in a large group, you may wish to guide the students yourself.

Textbooks and Reference Books



The package includes references to a textbook. The textbook for this course is *Science Directions 9* published by John Wiley and Sons.

Materials, Media, and Equipment

Mandatory Components

Equipment (Hardware)	Media	Materials
		• LFM for Science 9 • one complete set of module booklets (6) and assignment booklets (6) for each student • There is a final test. • For additional materials see the module introductions and the listings for each activity within the modules that follow.

Optional Components

Equipment (Hardware)	Media	Materials
• VCR	• videocassettes Videocassettes used in the course may be available from your regional media centre or ACCESS Network.	
• audiocassette player	• prepared audiocassettes featuring a teacher guide	

Using This Learning Package in the Classroom

Conventional Classroom

Whether your classroom has desks in rows or tables in small groups, you may be most comfortable with a learning system that you can use with all your students in a paced style. In other words, you may want a package that will suit all of your students, so they can move through the materials as one group or several small groups. Because these materials contain different routes or pathways within each unit, they can address various learning styles and preferences. The materials also include many choices within the activities to cater to different thinking levels and ability levels. Because of their versatility and flexibility, these materials can easily suit a conventional classroom.

Open-Learning Classroom

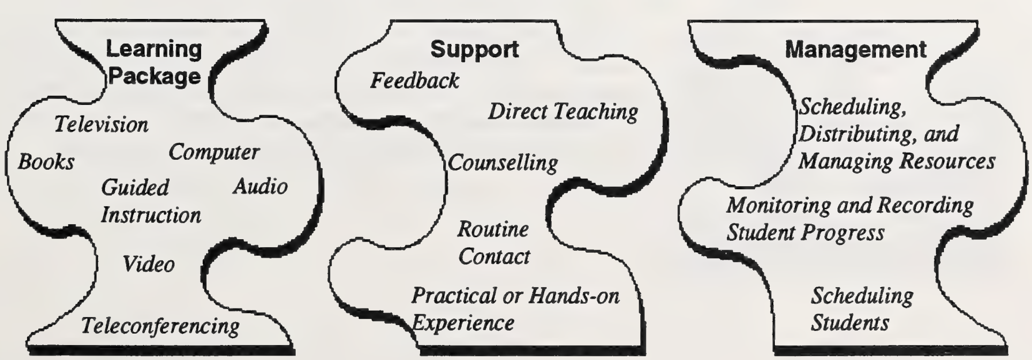
Open learning is the concept of opening up opportunities by overcoming barriers of time, pace, and place by giving the learners a package specially designed to enable them to learn on their own for at least some of the time.

Such a concept is not new. Many teachers can recite attempts to establish an individualized learning system as they recognized the importance of trying to personalize courseware to meet each individual student's needs. But these efforts often failed due to lack of time and lack of quality materials that conformed to Alberta specifications.

Due to advanced educational technology and improved Alberta-specific learning packages, a student-centred approach is now possible. Improved technology now allows us to provide support to learners individually, regardless of their pace or location. A teacher cannot be in twenty-eight places at one time offering guidance. However, media and a well-designed learning package can satisfy individual needs. Technology can also help provide an effective management system needed to track the students as they progress independently through the materials.

The key to a successful open-learning system depends on three vital elements: a learning package specially designed to enable students to learn effectively on their own for at least some of the time; various kinds of learner support; and a management system and style that ensures that the open-learning system runs smoothly.

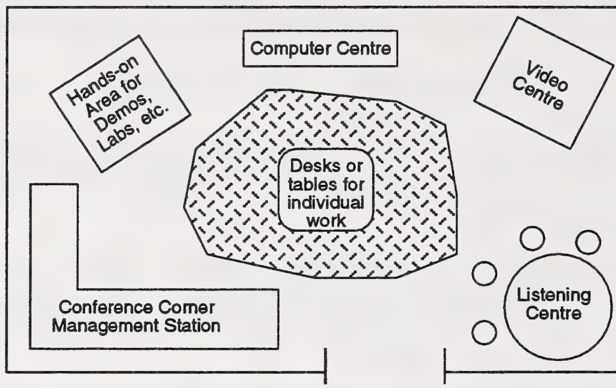
The Key to a Successful Open-Learning System



Learning Package

The specially designed learning package needed for a successful open-learning system has been developed for you. The objectives teach current Alberta specifications using strategies designed for individualized instruction. As the learning facilitator, you need to be sure to have all the components in the learning package available to students as needed.

If adequate numbers of media are available to satisfy the demand, a centre can be established for specific media.



You may not have the luxury to have enough hardware to set up a permanent video or computer centre in your classroom. In that case, students should be encouraged to plan ahead. Perhaps every three to five days they should preview their materials and project when they would need a certain piece of media. This would allow you to group students, if necessary, or reserve media as required.

Support

Support is definitely a key element for successful learning, and when you're planning an individualized, non-paced program, you need to carefully plan when and how support will be given.

The materials contain a form of consistent support by providing immediate feedback for activities included in the module booklet.

The answers, explanations, and examples for each of the module activities are included in this LFM. You may decide to set up an answer station with colour-coded cards, or you may want the students to come to you to discuss the activity together. As you and the student become more comfortable with an individualized system, you might increase the student's responsibilities – spot checking only to reinforce proper behaviour and to assess the student's day-to-day progress.

As the learning facilitator, you may be needed to offer more personal guidance to those students having difficulty, or you may need to reinforce the need for students to do these activities carefully before attempting the assignments in the assignment booklet.

The activities include choices and pathways. If a student is having difficulty, you may need to encourage that student to work on all the choices rather than one. This would provide additional instruction and practice in a variety of ways.

Another form of support is routine contact with each individual. This might be achieved with a biweekly conference scheduled by you, or as students reach a certain point (e.g., after each section is completed), they may be directed to come to the conference area.

Special counselling may be needed to help students through difficult stages. Praise and encouragement are important motivators, particularly for those students who are not used to working independently.

Direct teaching may be needed and scheduled at certain points in the program. This might involve small groups or a large group. It might be used to take advantage of something timely (e.g., election, eclipse, etc.), something prescheduled like the demonstration of a process, or something involving students in a hands-on, practical experience.

Support at a distance might include tutoring by phone, teleconferencing, faxing, or planned visits. These contacts are the lifeline between learners and distance education teachers, so a warm dialogue is essential.

Management

Good management of an open-learning system is essential to the success of the program. The following areas need action to ensure that the system runs smoothly:

- Scheduling, Distributing, and Managing Resources – As discussed earlier, this may require a need for centres or a system for students to project and reserve the necessary resources.

- Scheduling Students – Students and teachers should work together to establish goals, course completion timelines, and daily timelines. Although students may push to continue for long periods of time (e.g., all morning), teachers should discourage this. Concentration, retention, and motivation are improved by taking scheduled breaks.

- Monitoring Student Progress – You will need to record when modules are completed by each student. Your data might also include the projected date of completion if you are using a student contract approach.

Sample of a Student Progress Chart

		Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Final Test
Billy Adams	P							
	A							
Louise Despins	P							
	A							
Violet Klaissian	P							
	A							
P = Projected Completion Date A = Actual Completion Date								

The student could keep a personal log as well. Such tracking of data could be stored easily on a computer.

- Recording Student Assessments – You will need to record the marks awarded to each student for work completed in each module assignment booklet. The marks from these assignment booklets will contribute to a portion of the student's final mark. Other criteria may also be added (a special project, effort, attitude, etc.). Whatever the criteria, they should be made clear to all students at the beginning.

Sample of a Student Assessment Chart

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Year's Average	Final Test	Final Mark
Billy Adams	67	65	54	47	78	67	63	77	66
Louise Despins	43	50	54	55	48	42	49	64	52
Violet Klaissian	65	65	66	68	67	70	67	68	67

Letter grading could easily be substituted.

- Recording Effectiveness of System – Keep ongoing records of how the system is working. This will help you in future planning.

Sample of a System Assessment Chart

Module 1			
Date	Module Booklet	Assignment Booklet	Resources/Media

The Role of the Teacher in an Open-Learning Classroom

The teachers in a conventional classroom spend a lot of time talking to large groups of learners. The situation in open learning requires a different emphasis. Teachers will probably meet learners individually or in very small groups.

With this approach it is necessary to move beyond the idea of a passive learner depending largely on a continually supportive teacher. The teacher must aim to build the student's confidence, to stimulate the learner into self-reliance, and to guide the learner to take advantage of routes that are most meaningful and applicable to the learner.

These materials are student-centred, not teacher-centred. The teacher needs to facilitate learning by providing general support to the learner. Also, the teacher must ensure that all science experiments are done in a safe manner.

Evaluation

Evaluation is important to the development of every learner. Data gathering and processing, and decision making, at the student and teacher level, serve as means of identifying strengths and weaknesses.

These specially designed learning packages contain many kinds of informal and formal evaluation.

Observation

In the classroom the teacher has the opportunity to see each student perform every day and to become aware of the level and nature of each student's performance.

Observations are more useful if they are recorded in an organized system. The following list of questions is a sample of types of observations and how they can be collected.

Observation Checklist

	B. Adams	L. Despins	V. Klaissian	H. Smith	K. Dalley
1. Does the student approach the work in a positive manner?					
2. Is the student struggling with the reading level?					
3. Does the student make good use of time?					
4. Does the student apply an appropriate study method?					
5. Can the student use references effectively, etc.?					

Observation may suggest a need for an individual interview with a student.

Individual Conferences

Individual conferences may be paced (scheduled) by the calendar or at certain points in the module, or they may be set up only as needed or requested.

During these conferences teachers can determine the student's progress and can assess the student's attitudes toward the subject, the program, school, and self, as well as the student's relationship with other students. With guided questions the teacher can encourage oral self-assessment; the student can discuss personal strengths or weaknesses in regard to the particular section, module, or subject area.

Self-Appraisal

Self-appraisal helps students recognize their own strengths and weaknesses. Through activities that require self-assessment, students also gain immediate feedback and clarification at early stages in the learning process. Teachers need to promote a responsible attitude toward these self-assessment activities. Becoming effective self-assessors is a crucial part of becoming autonomous learners. By instructing, motivating, providing positive reinforcement, and systematically supervising, the learning facilitator will help students develop a positive attitude toward their own progress.

For variation, students may be paired and peer-assessing may become part of the system. The teacher may decide to have the student self-assess some of the activities, have a peer assess other activities, and become directly involved in assessing the remainder of the activities.

When the activities have been assessed, the student should be directed to make corrections. This should be made clear to students right from the start. It is important to note the correct association between the question and the response to clarify understanding, aid retention, and be of use for study purposes.

Many of the activities include choices for the student. If the student is having difficulty, more practice may be warranted, and the student may need to be encouraged to do more of the choices.

Each section within a module includes additional types of activities called Extra Help and Enrichment. Students are expected to be involved in the decision as to which pathway best suits their needs. They may decide to do both.

Self-appraisal techniques can also be introduced at the individual conferences. Such questions as the following might be included:

- What steps are you taking to improve your understanding of this topic?
- What method of study do you use most?
- How do you organize your material to remember it?
- What steps do you follow when doing an assignment in your assignment booklet?
- What could you do to become an even better reader?
- Do you have trouble following directions?
- Did you enjoy this module?

A chart or checklist could be used for recording responses.

Informal Evaluation: Assignments

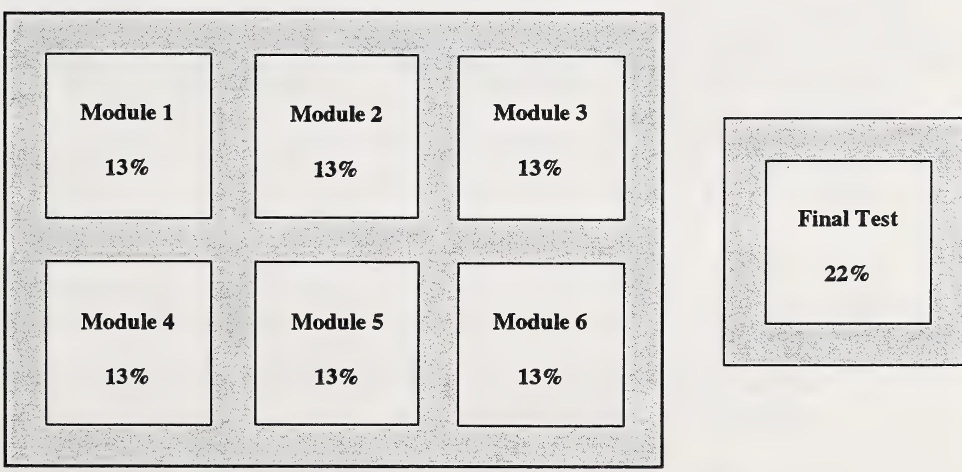
Informal evaluation, such as the assignments included in each module, are an invaluable aid to the teacher. They offer ongoing assessment information about the student's achievement and the behaviour and attitudes that affect that achievement.

Each module contains a separate booklet called the Assignment Booklet. This booklet assesses the knowledge or skills that the student has gained from the module. **The student's mark for the module may be based solely on the outcome of learning evident in the assignment booklet; however, you may decide to establish a value for other variables such as attitude or effort.** It is important that you establish at the beginning which outcomes will be evaluated, and that all students clearly understand what is expected.

Final Test

All LFMs include a formal final test which can be photocopied for each member of the class. The test, closely linked to the learning outcomes stated in the module booklets, gives the teacher precise information concerning what each student can or cannot do. Answers, explanations, and marking guides are also included.

The value of the final test and each module is the decision of the classroom teacher. Following is a suggestion based on equal weighting of the modules, where approximately six weeks of classes are allotted for each module and the course is completed in one school year.



Introducing Students to the System

Your initiation to these learning materials began with a basic survey of what was included and how the components varied. This same process should be used with the class. After the materials have been explored, a discussion might include the advantages and the disadvantages of learning independently or in small groups. The roles of the students and teacher should be analysed. The necessary progress checks and rules need to be addressed. Your introduction should motivate students and build a responsible attitude toward learning autonomously.

Skill Level

It is important for students to understand that there are certain skills that they will need in order to deal successfully with the course materials. They are listed below:

- understanding and using instructional materials (table of contents, index, list of illustrations, appendices, bibliography, and glossary)
- interpreting and making maps, graphs, and charts
- using reference materials
- recognizing special symbols
- using a scientific calculator

Other general skills are using reliable study methods, outlining, and learning to read at a flexible rate.

To decide the level and amount of instruction needed to accommodate the varied levels among students, you may wish to prepare and administer skill inventories or pretests. If most students need help with a particular skill, you may want to plan a total class instructional session. If only certain students lack a skill, you may want to set up a temporary skill group to help students who need it, or you may want to develop a skills file for this purpose.

Reading Level

These course materials are largely print based, but poorer readers need not be discouraged. It is important that you assure the students that these materials have been designed for easy reading. The authors have employed special strategies that lower and control the reading level. Some of them are

- the conscious selection of vocabulary and careful structuring of sentences to keep the materials at an independent reading level
- the integration of activities, examples, and illustrations to break text into appropriate-sized chunks
- the inclusion of many kinds of organizers (advance, graphic, intermediate, concept mapping, post organizers) to help give students a structure for incorporating new concepts

- the recognition that vocabulary and concepts are basic to understanding content materials and, thus, must be handled systematically (defined in context, marginal notes, footnotes, and often in a specialized glossary)

- the acknowledgement that background knowledge and experience play a vital role in comprehension

- the systematic inclusion of illustrations, optional videos (to help poorer readers and visual learners), and audiocassettes as an alternative to print-based learning

- a variety of formats (paragraphs, lists, charts, etc.) to help poorer readers who do not absorb or retain main ideas easily in paragraph format

- the inclusion of media pathways and activity choices to encourage an active rather than passive approach

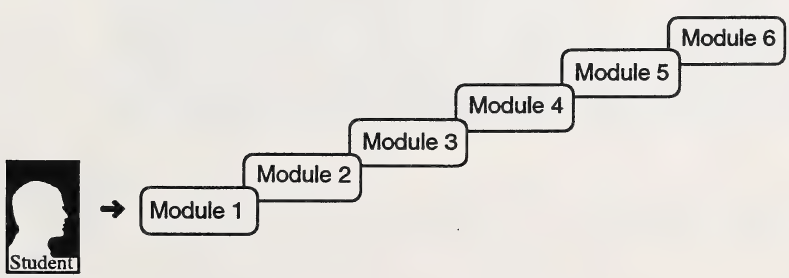
- instruction in a meaningful setting rather than in a contrived, workbook style

- using purposeful reading, viewing, and doing to produce better interpretation of the course materials

- the recognition that students need structured experiences when reading, viewing, or listening to instructional materials: developing pupil readiness, determining the purpose, providing guided instruction and feedback, rereading if necessary, and extending (This structure closely resembles the reading process.)

To help make the learning package more readable, you can begin your module preparation by reading (viewing, listening to) all the related materials that are going to be used. You need a solid background in order to assess and develop a background knowledge for students. The students' experiential bases may be assessed through brainstorming sessions concerning the topic, or by using visuals and guided questions to predict what the topic might be about.

Normally, students should do the six modules in numerical order. However, Module 6 involves activities that are better done outside during the frost-free season, and so you may want to reschedule Module 6.



SCIENCE 9

Module 1

Chemical Properties and Changes

LEARNING FACILITATOR'S MANUAL

Distance Learning

Alberta
EDUCATION

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Module 1 – Chemical Properties and Changes: Overview

The major emphasis of this module is the nature of science.

In this module students are introduced to the chemical properties of common substances. The students will learn to distinguish between chemical and physical changes and to recognize examples of chemical changes that occur in their environment. Some factors that affect reaction rates are studied. The students also focus on the chemistry of acids and bases. Students will learn that common household substances have physical and chemical properties. They will also learn to recognize that some household chemicals have hazardous properties when involved in chemical reactions.

Module 1
Chemical Properties and Changes

Section 1
Chemicals and Pure Substances

Section 2
Changes and Chemical Reactions

Section 3
Acids and Bases

Section 4
Controlling Chemical Reactions

Classroom Opener

Have students examine the pictures in the textbook introduction to Unit 1. Have students identify the changes in chemicals that are represented by the pictures. Tell the students that these pictures, along with hints about their significance, can be found throughout Unit 1. For example, the parliament buildings show corroded copper roofs, the rock face in the quarry shows an explosion, and the hydrogen peroxide is a man-made chemical. Students should become more aware that chemistry deals with such events and materials and is important in many aspects of everyday life.

Media

Video cassettes may be available from your regional media centre or the ACCESS Network.

The following video has been included in this module:

Chemistry in Everyday Life

Materials and Equipment

The necessary materials and equipment are listed under each activity. In planning for the acquisition of these items, you may find it useful to preview these lists.

Several activities call for the use of a test tube rack; however, test tubes may be placed in tall glass cups for support. Make sure the glasses provide enough support by first placing water-filled test tubes in them. If the glasses provide stable support for full test tubes, the glasses will safely support test tubes partially filled with chemicals.

The materials must be handled safely. In general, if chemicals are spilled on the work surface, soak them up with a sponge. Wear safety gloves while doing this procedure. Then dilute the work surface with excess water and rinse the chemicals down the drain. Wash the sponge carefully, making sure the chemical residues have been washed away. The chemicals used for the laboratory activities are not likely to damage the work surface (i.e. counter or table); however, it is recommended that students use a thick layer of paper towel or a rubber mat to protect the work surface from any spills that may occur.

If chemicals come in contact with clothing, remove the clothing immediately and rinse thoroughly with excess water. Wear protective plastic gloves while doing this procedure.

If the students' hands come into contact with chemicals, they are to be washed thoroughly with water and then soap and water.

It is recommended that students wear some eye protection (safety glasses) and some protective clothing (i.e. lab coat or smock) when dealing with chemicals.

It is imperative that students do all their lab work near the sink or where water is available.

Students must remember to wash their hands thoroughly after each experiment.

If either an acid or a base gets into students' eyes, wash eyes with cold water for 25 minutes and seek medical attention immediately.

Caution: Students will be working with chemicals in many of the activities in this module. Be sure that proper supervision is provided while students do activities involving chemicals and that proper safety precautions are followed.

Evaluation

The mark in this module will be determined by students' work in the Assignment Booklet. Students must complete all assignments. In this module students are expected to complete four section assignments and a final module assignment.

The assignment breakdown is as follows:

Section 1 Assignment	**20%**
Section 2 Assignment	**20%**
Section 3 Assignment	**25%**
Section 4 Assignment	**15%**
Final Module Assignment	**20%**
TOTAL	**100%**

Section 1: Chemicals and Pure Substances

Students often wonder exactly what a chemical is. They probably already have their own definition and understanding of what a chemical is and what the study of chemistry is all about. It is important to use this fascination as a motivating starting point to introduce students to an understanding of chemistry.

In this section students will develop an understanding of the relationship between chemicals and matter. They will learn some of the properties of matter, and how to collect data about these properties to help classify the matter. They will demonstrate the skills of observation and inference as they gather and interpret data.

Section 1: Activity 1

The following materials are needed for this activity:

- hand lens
- sealed vials or sealed petri dishes labelled A, B, C, and D containing small amounts of the substances shown in the table. The containers should be sealed with tape or glue and have permanent identification for repeated use and safety.

Unknown	Substance
A	sodium chloride
B	sulphur
C	icing sugar
D	calcium hydroxide

- ten small bottles with screw caps and partially filled with the substances shown in the following table. The bottles should be labelled E, F, G, etc.. Additional information should be included on the label, as shown in the table on the following page. The bottles should be capped and sealed. With permanent labelling and proper sealing, the bottles can be used repeatedly and will be safe to handle.

Unknown	Substance	Information on Label
E	ethanol/water solution	boiling point 90°C
F	sulphur and sucrose mix	none to be given
G	glycerol	freezing point 18°C
H	salt/water solution	freezing point –2°C
I	copper (II) sulphate solution	none to be given
J	copper (turnings are the cheapest form)	density 9.0
K	aluminum (metal shot)	density 2.7 g/cm^3
L	tin (science grade granules)	density 7.3 g/cm^3
M	steel (wool sliced up)	density 8.4 g/cm^3
N	water and aluminum shot	none to be given

1. How would you feel about your discovery?

   Answers will vary. Sample answer: I would feel excited and happy. My discovery may benefit many people and I might become wealthy.

2. What is chemistry concerned with?

   Chemistry is concerned with the properties of and changes in matter.

3. List four things that a chemist does.

   Chemists do the following things:

   - *observe properties and changes*
   - *develop models to explain observations*
   - *use knowledge to control changes*
   - *produce new kinds of chemicals with practical uses*

4. Which of the properties listed on page 3 of your text may be determined by the sense of sight?

   State, colour, texture, lustre, and crystal structure can all be determined by sight.

5. Which of the properties listed on page 3 involves the sense of smell?

   Odour involves the sense of smell.

6. Briefly describe the safe method that you should use to identify odours.

   To smell an unknown substance or a chemical, hold the container away from your nose. Then, using your hand as a fan, waft the fumes towards your nose.

7. Which property listed on page 3 involves a sense that should not be tested in a science laboratory or classroom?

   The sense of taste should not be used in the lab to determine properties unless you have been specifically requested to do so. It can be very dangerous.

8. Name two properties that can only be determined by making a careful measurement.

   Solubility, freezing and melting point, boiling point, and density are properties which require careful measurement in order to be determined.

9. After reading the properties listed in Table 1-2, what do you infer the identity of each of the substances to be?

   a. Substance A *is water.*

   b. Substance B *is icing sugar.*

   c. Substance C *is diamond.*

10. Do question 1 of Analysis.

    Student answers will vary.

    Substance A is water. The freezing point of 0°C and the insolubility in oil were the properties used to identify substance A.

    Substance B is icing sugar. It was identified by its property of turning black and burning.

    Substance C was identified as diamond. The combination of hardness, the crystal structure, and size was used.

11. Based on the problem statement, what are you really trying to find out in this investigation?

    You are trying to identify unknown substances based on their physical properties.

12. What should you do if you spill a chemical?

    Immediately wash the spill with plenty of water.

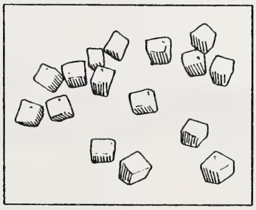
13. What should you do if your skin comes in contact with one of the chemicals?

    You would need to wash the materials off of your skin with plenty of cold water.

14. What is the appearance of Unknown A?

    Answers may vary. Unknown A may be described as small clear crystals with similar shapes.

15. Sketch Unknown A.



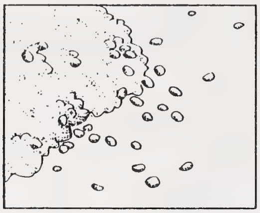
16. Infer the identity of Unknown A.

Unknown A is sodium chloride (salt).

17. What is the appearance of Unknown B?

Answers may vary. Unknown B may be described as a fine yellow powder.

18. Sketch Unknown B.



19. Infer the identity of Unknown B.

Unknown B is sulphur.

20. What is the appearance of Unknown C?

Answers may vary. Unknown C may be described as a powdered white solid.

21. Sketch Unknown C.

22. Infer the identity of Unknown C.

    Unknown C is sucrose (icing sugar).

23. What is the appearance of Unknown D?

    Unknown D may be described as fine white powder. Students may be able to see some very tiny crystals.

24. Sketch Unknown D.

25. Infer the identity of Unknown D.

    Unknown D is calcium hydroxide (slaked lime).

26. Answer question 1 of Analysis.

    The students will probably find that colour is the easiest property to use to distinguish between the unknowns. In this case, sulphur would be the easiest substance to identify. It is possible that some students may bypass the answer "colour" as being too easy or obvious. In this case they will probably talk about the crystal structure. If they answer in this way, they have not answered incorrectly, but a discussion of what led them to their answer may be worthwhile.

27. In addition to inferring the identity of the pure substances, what is the problem in this investigation?

    The problem is classifying unknown substances as either pure substances or mixtures, and classifying mixtures as mechanical mixtures or solutions.

28. Complete the chart.

Sample Number	Observed Properties	Information on Label	Classification	Reasons for Classification	Substance(s)
E	*colourless liquid*	*boiling point 90°C*	*solution*	*boiling point is not on list*	*probably mixture with water*
F	*yellow and white powder*	*none*	*mechanical mixture*	*two observable parts*	
G	*colourless liquid*	*freezing point 18°C*	*pure substance*	*freezing point found on list*	*glycerol*
H	*colourless liquid*	*freezing point –2°C*	*solution*	*freezing point not on list*	*probably contains water*
I	*blue coloured liquid*	*none*	*solution*	*nothing on list to suggest identity*	*any answer here would be a guess*
J	*golden or copper coloured solid*	*density 9.0 g/cm³*	*pure substance*	*identity from density on list*	*copper*
K	*dull silvery solid*	*density 2.7 g/cm³*	*pure substance*	*identity from density on list*	*aluminum*
L	*dark metallic coloured solid*	*density 7.3 g/cm³*	*pure substance*	*identity from density on list*	*tin*
M	*shiny silvery coloured solid*	*density 8.4 g/cm³*	*solution*	*density is not on list*	*the student may guess steel*
N	*clear liquid and a solid material*	*none*	*mechanical mixture*	*two obvious things here*	*water and metal*

29. Which of the unknowns are pure substances?

Unknowns G (glycerol), J (copper), K (aluminum), and L (tin) are pure substances.

30. Which of the unknowns are mechanical mixtures?

    Unknowns F and N are mechanical mixtures.

Section 1: Activity 2

The following materials are needed for this activity:

- small test tube about half full of *p*-dichlorobenzene
- thermometer
- large test tube in which the small test tube can be placed
- heat source
- 250 mL beaker or metal pot
- another container (e.g., a beaker for a cold-water bath)
- a wire mat may be used if using a glass beaker on the heat source
- oven mitts
- a test tube clamp may be used to hold the heated test tubes
- an apron
- safety glasses
- 100 mL graduated cylinder
- 125 mL Erlenmeyer flask or 250 mL beaker
- sodium chloride (table salt)
- balance scale or 5 mL spoon or teaspoon

After the first investigation is completed, students are to ask you about the disposal or re-use of the test tubes of *p*-dichlorobenzene. The test tubes may be stoppered for re-use by the next group of students. When the test tubes are no longer required, they may be disposed of in the garbage.

1. Record the temperature at 0.5 min (30 s) intervals until the *p*-dichlorobenzene appears to be solid. (If the experiment takes additional time, space is provided so that you can continue adding to your table.)

   Student data will vary, but the temperatures should increase over time. Check to see that the student has recorded temperatures at 0.5 min intervals. A few sample readings indicating the range within which the temperatures are expeced to be are given in the chart on the following page.

Temperature of *p*-dichlorobenzene during Solidification

Time (min)	Temperature (° C)	Time (min)	Temperature (° C)	Time (min)	Temperature (° C)
0.0	*70 – 80*	3.5		7.0	
0.5		4.0	*40 – 60*	7.5	
1.0		4.5		8.0	*30 – 40*
1.5		5.0		8.5	
2.0		5.5		9.0	
2.5		6.0		9.5	
3.0		6.5		10.0	

2. Record the temperature at 0.5 min (30 s) intervals until the *p*-dichlorobenzene appears to be completely melted. (If the experiment takes additional time, space is provided so that you can continue adding to your table.)

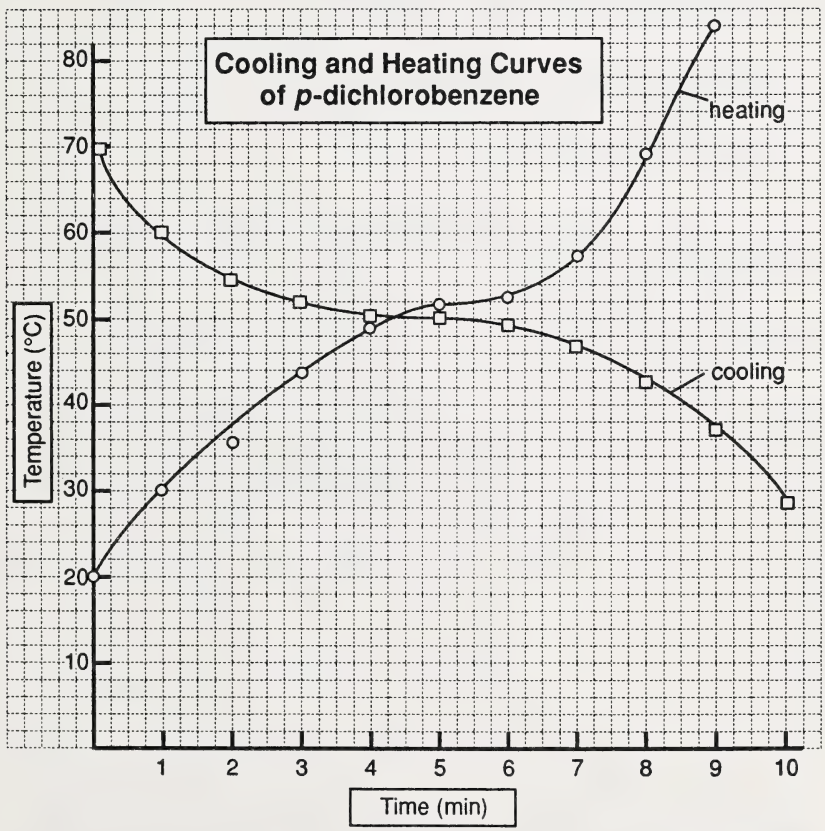
   Student data will vary, but the temperatures should increase over time. Check to see that the sudent has recorded temperatures at 0.5 min intervals. You can expect the readings to fall within the range of the few sample readings given in the following chart.

Temperature of *p*-dichlorobenzene during Melting

Time (min)	Temperature (° C)	Time (min)	Temperature (° C)	Time (min)	Temperature (° C)
0	*20 – 30*	3.5	*40 – 60*	7.0	
0.5		4.0		7.5	
1.0		4.5		8.0	*70 – 80*
1.5		5.0		8.5	
2.0		5.5		9.0	
2.5		6.0		9.5	
3.0		6.5		10.0	

3. Graph your results on the following grid. Place time on the horizontal axis and temperature on the vertical axis. Place both sets of data on the same graph. Correctly label the curves as *heating* and *cooling.*

   The curves may be spread over a longer period of time but the plateaus should be at about 50°C to 54°C. Check to see that the students used the data from their charts for their graphs. The completed graph should look similar to the following sample graph.



4. How many times does the curve change on the heating graph?

   It changes three times. It goes up, levels off, and then goes up again.

5. How many times does the curve change on the cooling graph?

   It changes three times. It goes down, levels off, and then goes down again.

6. What is happening to the *p*-dichlorobenzene when the lines of the graph are the flattest?

   Answers may vary. The student may answer that the substance is melting or freezing or that there is a change of state.

7. What is the melting point of *p*-dichlorobenzene?

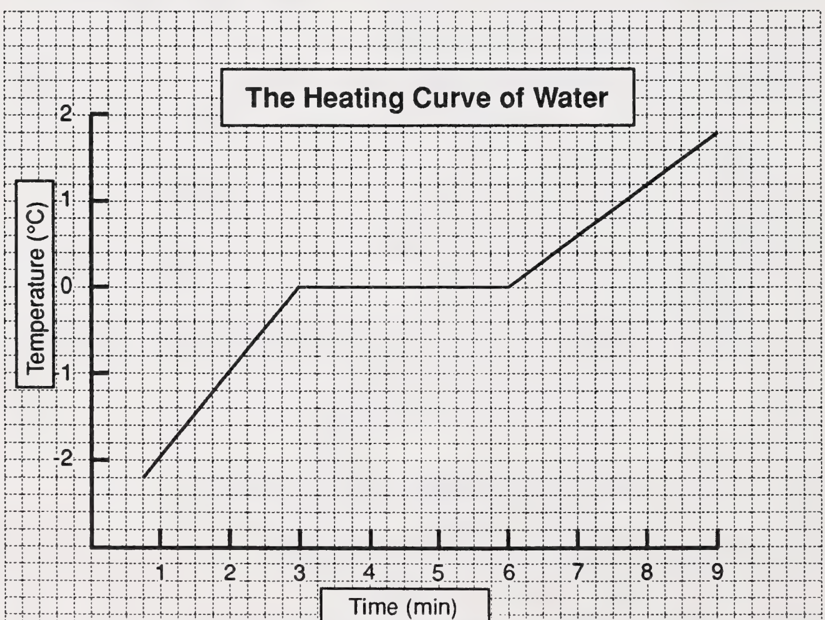
   Answers may vary, but should be close to 53°C.

8. What is the freezing point of *p*-dichlorobenzene?

   Answers may vary, but should be close to 53°C.

9. On the following grid, predict what the graph for the melting of water would look like. Label the axes with the appropriate units.

   The graph should show the flat portion at 0°C. The length of the flat portion may vary.



10. What is the mass of the three bolts?

    Their mass is 100 g.

11. What is the volume of the three bolts?

    Their volume is 12.5 mL (e.g., Volume = 62.5 mL – 50 mL = 12.5 mL).

12. What is the density of the metal?

    The density is 8 g/mL (e.g., mass/volume = 100 g/12.5 mL = 8 g/mL).

13. Identify the metal that the bolts are probably made from.

    Iron has a density of 7.9 g/mL. This is the closest to 8 g/mL, so the bolts are probably iron.

14. Do question 2 of Skillbuilding Practice 3-1 on page 352 of your textbook.

    The mass is 95 g – 60 g = 35 g.

    The volume is 70 mL – 40 mL = 30 mL.

    The density is $\frac{35\ g}{30\ mL} = 1.17\ g/mL$

15. Record the mass of sodium chloride which dissolved in 25 mL of water.

    About 9 g to 10 g of salt will dissolve in 25 mL of water.

16. Calculate how many grams of sodium chloride will dissolve in 100 mL of water at room temperature (Hint: 100 mL is four times more than 25 mL).

    This answer should be four times greater than the answer listed above. 25 mL is one-fourth of 100; therefore, four times as much would dissolve in 100 mL. Answers should be in the range of 36 to 40 g/100 mL.

17. If you assume that the water you used in this investigation was at room temperature, what is the solubility of sodium chloride at room temperature?

    This question is checking for understanding of solubility. Answers should be in the range of 36 to 40 g/100 mL.

18. If you were given 23.5 g of a substance which has a solubility of 48 g/100 mL at room temperature, could you dissolve all of this substance in 50 mL of water?

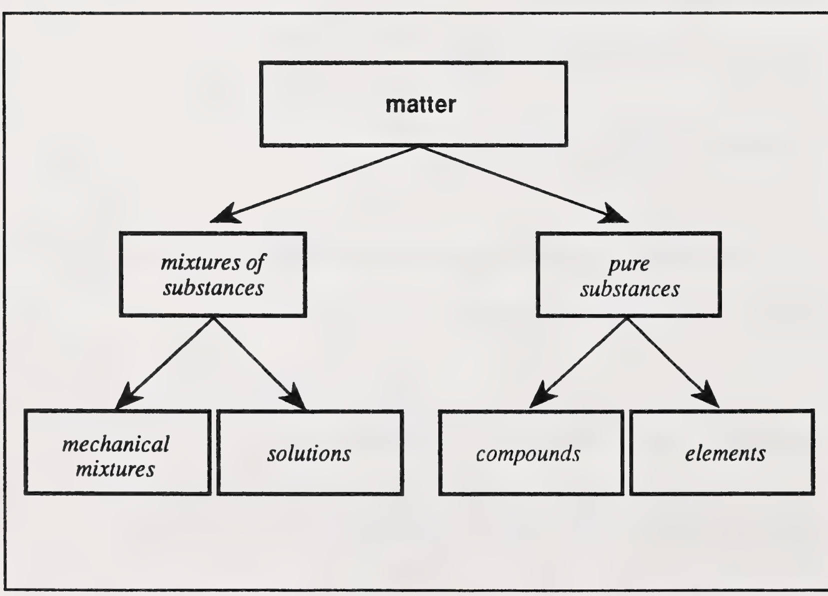
    Yes, because 23.5 g in 50 mL is only 47 g for 100 mL, and this is less than the solubility of the substance.

Section 1: Activity 3

1. Which two categories can pure substances be divided into?

   Pure substances are either compounds or elements.

2. Complete the classification scheme by filling in the appropriate blanks in the following diagram.



Section 1: Follow-up Activities

Extra Help

1. If a material has separate parts which are visible, how is it classified?

   It is classified as a mechanical mixture.

2. Which of the three unknowns has separate parts which are visible?

   Unknown N has separate parts which are visible.

3. How do you classify Unknown N?

   Unknown N is a mechanical mixture.

4. Which of the unknowns has a property which is listed in Table 1-4 of your textbook?

   Unknown K has a listed property.

5. Is your observation of this unknown the same as the appearance which is listed for the pure substance listed in Table 1-4?

   Yes, it is.

6. How do you classify Unknown K?

   Unknown K is a pure substance.

7. Which unknown's melting point is not included in Table 1-4?

   Unknown H has a melting point that is not listed.

8. What inference can you make about the classification of Unknown H?

   Unknown H must be a solution of more than one substance (from table 1-4) since its melting point is not listed, but is just below that of water.

Enrichment

1. Refer to Activity 1-5 on page 15 of your textbook. Then do textbook questions 1 and 2.

   Textbook question 1:

   The letters represent the elements that are present in the molecules. The numbers (called subscripts) tell how many atoms of each element are present.

   $NaHCO_3$ *means one atom each of sodium, hydrogen, and carbon, and three atoms of oxygen.*

   $CaHCO_3$ *means one atom each of calcium, hydrogen, and carbon, and three atoms of oxygen.*

   $CuSO_4$ *means that there is one atom each of copper and sulphur, while there are four atoms of oxygen.*

   NaCL indicates that there is one atom each of sodium and chlorine.

   $C_9H_8O_4$ *reveals a molecule made up of nine carbon atoms, eight hydrogen atoms, and four oxygen atoms.*

   Textbook question 2. (a):

   H_2. *This is an element because it is made up of only one kind of atom. Students will learn a great deal more about this topic in high school chemistry. Interested students are sure to find books on this topic in most libraries.*

   Textbook question 2. (b):

   $NaNO_3$. *This substance is a compound since three elements are involved.*

   Textbook question 2. (c):

   C_3H_8. *This substance is a compound since two elements are involved.*

Section 1 Assignment

Marking Guide: Suggested values are given in brackets.

1. Refer to page 19 of your textbook. Do Checkpoint questions 1. (a), 1. (b), 1. (c), 2. (a), 2. (b), 2. (c), 3. (a), 3. (b), and 3. (c). (Question 1 can be marked out of a total of 10 marks.)

   Textbook question 1. (a): (1 mark)

   A property of a substance is a feature or distinguishing characteristic which helps to describe or identify the substance.

Textbook question 1. (b): (1.5 marks)

The student may have listed any three of the following: state, colour, lustre, texture, or crystal structure.

Textbook question 1. (c): (1.5 marks)

The student may have listed any three of the following: solubility, melting point, freezing point, boiling point, ability to burn, decompose, explode, or react with certain other substances.

Textbook question 2. (a): (1 mark)

Tin has a lower melting point than iron. Tin also has a lower density than iron. Tin has a more yellowish tinge in colour, while iron is grey.

Textbook question 2. (b): (1 mark)

Both are white solids, but sugar will not boil. Sugar also has a much lower melting point. Sugar is not as dense as salt.

Textbook question 2. (c): (1 mark)

Water has a much higher melting point than alcohol. Alcohol is not as dense as water.

Textbook question 3. (a): (1 mark)

This group belongs to the mechanical mixture category. Salt water is a solution and does not belong.

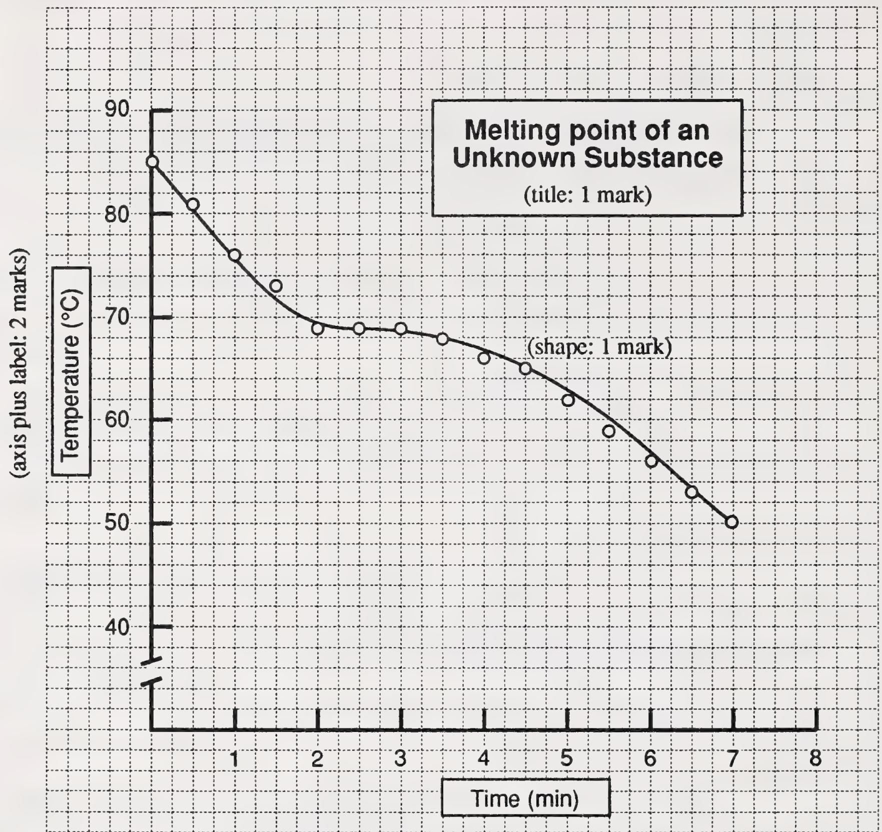
Textbook question 3. (b): (1 mark)

This group belongs to the compound category. Salt water is a solution and does not belong.

Textbook question 3. (c): (1 mark)

This group belongs to the compound category. Oxygen is an element and does not belong.

2. Use the information entered in the table to draw a graph on the grid provided. (This question can be marked out of 6 marks.)



(axis plus label: 2 marks)

3. What is the melting temperature of the substance? (1 mark)

The melting point is 69°C.

4. Determine the solubility of copper (II) sulphate in warm water. (1 mark)

The solubility is 200 g/100 mL in warm water.

Comment:

Solubility is expressed as the number of grams of matter that will dissolve in 100 mL of water or other solvent at a certain temperature, so if 50 g of copper (II) sulphate dissolve in 25 mL of warm water, then 200 g will dissolve in 100 mL of warm water.

5. Determine the solubility of copper (II) sulphate in cold water. (1 mark)

   The solubility is 32 g/100 mL in cold water.

6. What effect does the temperature of the water have on the solubility of copper (II) sulphate? (1 mark)

   The solubility increases as the water temperature increases. More copper (II) sulphate is soluble in warmer water.

Section 2: Changes and Chemical Reactions

Students are introduced to the concept of chemical and physical changes by classifying various types of change. Students learn how to determine types of change, examine how chemical change can be used as a method of chemical identification, and look at the relationship between energy and chemical change.

Section 2: Activity 1

The following materials are needed for this activity:

- safety glasses
- approximately 2 g of copper (II) sulphate
- a stopper and test tube
- test tube rack
- a 5 mL spoon or teaspoon to measure and transfer the copper (II) sulphate
- piece of steel wool prewashed in detergent and measuring about 1 cm by 1 cm by 1 cm
- 2 cm of magnesium ribbon
- about 15 mL of dilute hydrochloric acid
- stirring rod
- test tube containing potassium iodide solution
- test tube containing lead (II) nitrate solution
- 5 to 10 mL of sodium silicate (water glass)

At the end of this activity students are to ask you how to dispose of the waste produced by the mixing of potassium iodide and lead (II) nitrate solutions. You may suggest that this waste be poured into a 250 mL beaker mixed with at least 5 mL of sodium silicate solution (water glass) and then be allowed to stand for 5 minutes. The beaker contents may then be safely flushed down the toilet. The test tubes that contained the potassium iodide solution and the lead (II) nitrate solution should be given to you so that they can be properly rinsed and safely disposed of into the garbage.

If you are working with many students, you may decide to have all the waste produced in this activity added to a partially filled container of sodium silicate solution. This container may then be taken to a landfill site for disposal.

1. What is formed in any chemical change?

   One or more new substances are formed in any chemical change.

2. In what ways is a physical change different from a chemical change?

   No new substance is formed in a physical change.

3. List five clues that may indicate a chemical change.

   The following clues indicate a chemical change.

   - *new colour appears*
   - *heat or light is given off*
   - *bubbles of gas are formed*
   - *solid material (precipitate) forms*
   - *the change is difficult to reverse*

4. Why do you need to consider more than one clue before you can indicate that a chemical change has taken place?

   Answers may vary. One clue by itself is not conclusive. For example, a physical change may also result in a colour change or the formation of gas.

5. Use your observations to complete the table.

Names of Starting Substances	Properties	Observations of Change after Mixing
water	*colourless liquid*	*The solid dissolved in the water to form a blue liquid.*
copper (II) sulphate	*blue crystals*	

6. What was the initial colour of the copper (II) sulphate?

   There were blue crystals with a hint of white dust on them.

7. What was the final colour after you mixed the two chemicals together?

A blue solution was formed.

8. Was there a change which may indicate a chemical change?

Yes, a colour change indicates a chemical change, but that was the only change that was observed. Answers may vary.

9. Was the change chemical or physical?

No conclusive answer can be given, but if the solution was left overnight, the crystals reformed. The change was not difficult to reverse, so the student could conclude that this is not a chemical change.

10. Use your observations to complete the table.

Names of Starting Substances	Properties	Observations of Change after Mixing
copper (II) sulphate solution	*blue liquid*	*There was a colour change (yellow colour).*
steel wool	*silvery gray*	

11. What was the colour of the steel wool at the beginning of this investigation?

The steel wool was grey or silvery coloured.

12. What was the colour of the steel wool after 10 minutes?

The steel wool started to turn yellow or copper colour after 10 minutes.

13. What was the colour of the copper (II) sulphate solution at the beginning of the investigation?

The copper (II) sulphate solution was blue at the beginning of the investigation.

14. What was the colour of the copper (II) sulphate solution at the end of the investigation?

The blue colour had faded and become light – almost yellow – by the end of the investigation.

15. Was there a change which may indicate a chemical change?

Yes, there was a colour change. This may indicate a chemical change.

16. Was the change chemical or physical?

The change was probably chemical since two things changed colour. Answers will vary.

17. Use your observations to complete the table.

Names of Starting Substances	Properties	Observations of Change after Mixing
dilute hydrochloric acid	*colourless liquid*	*Bubbles form as magnesuim ribbon gets smaller.*
magnesuim ribbon	*silvery shiny metal (solid)*	

18. Which of your observations may indicate a chemical change?

Bubbles of gas formed. This may indicate a chemical change.

19. Did a chemical or a physical change take place when you added the magnesium ribbon to the dilute hydrochloric acid?

A chemical change occurred. If allowed to go on long enough, all of the magnesium ribbon should have disappeared. This reaction would be hard to reverse. Answers will vary.

20. Use your observations to complete the table.

Names of Starting Substances	**Properties**	**Observations of Change after Mixing**
potassuim iodide solution	*clear colourless liquid*	*yellow solid (precipitate) forms*
lead (II) nitrate solution	*clear colourless liquid*	

21. Both the potassium iodide and the lead (II) nitrate are described as solutions. Which physical properties do they have that allow them to be described as solutions?

Both mixtures appear to be only one substance. This is the characteristic of a solution.

22. How would you classify the substance formed after you mixed the two solutions?

The substance that formed when the solutions were mixed is a mechanical mixture.

23. Was the change a physical change or a chemical change? Explain your answer.

The change was a chemical change. Both the colour change and the formation of a precipitate indicate a chemical change.

Comment:

At this point the student will ask you how to dispose of the waste produced by the mixing of potassium iodide and lead (II) nitrate solutions. The instructions for disposal are given at the start of this activity.

24. What is another term for chemical change?

Chemical reaction is another term for chemical change.

25. What is the difference between a reactant and a product?

Reactant refers to the substance or substances that are used up in a chemical reaction. Reactants are the chemicals that are present at the beginning of the chemical reaction. Products are chemicals formed as a result of the chemical reaction. Answers may vary.

Section 2: Activity 2

The following materials are needed for this activity:

- safety glasses
- 10 mL (2 teaspoons) of calcium hydroxide
- a seltzer tablet
- baking soda
- vinegar
- about 15 cm of rubber tubing to fit the glass tubing used
- test tube
- rubber stopper with about 12 cm of glass tubing inserted. Glass tubing should extend about 2 cm beyond the narrow end of the stopper. The stopper should fit the test tube used.
- small jar with a water tight lid (a small jam jar would be suitable)
- a straw
- a beaker
- other available materials that may be called for in the student-designed test for carbon dioxide

The students should be supplied with stoppers with the glass tubing (or rigid plastic tubing) already inserted. If you do allow students to insert the glass tubing themselves, make sure short pieces of tubing are used and that the ends of the tubing are smooth (have been fire polished). Make sure that students wear work gloves. The tubing should be lubricated with a bit of cooking oil and should be inserted with gentle pressure. The tubing should be rotated as it is inserted. Supervise this procedure closely.

The calcium hydroxide will be used to prepare a solution of calcium hydroxide (also called limewater). Instructions on how to prepare this solution are provided in the Student Module Booklet.

1. Tell what tests you would do to distinguish between oxygen and hydrogen.

    - *Test for oxygen*
      – light a wooden splint
      – blow out the flame to create a glowing splint
      – place the glowing splint into the unknown gas
      – if the splint bursts into flame, the gas is oxygen

    - *Test for hydrogen*
      – light a wooden splint
      – hold the burning splint in a small amount of the unknown gas
      – a loud "pop" sound indicates the presence of hydrogen

2. Why could you not use these same tests to determine if a gas is carbon dioxide?

    Carbon dioxide does not allow the flame to burn.

3. What is the problem for this experiment?

   How is carbon dioxide commonly produced? The students may have used their own words. The following is a sample. Is carbon dioxide produced by the reaction of seltzer tablets plus water, or by the mixing of baking soda plus vinegar?

4. Follow step 1 of the procedure. Give a reason for your answer to the question in step 1.

   Yes, exhaled breath contains carbon dioxide. It caused the limewater to turn cloudy.

5. Write a procedure for step 3 in the textbook.

   The procedure should be safe and require only materials that are available. The procedure should involve the following:

   - *a container with a one-hole stopper with glass tubing connected to a length of rubber tubing so that the gas can be bubbled through the limewater*
   - *mixing of the chemicals (seltzer tablet added to water, and baking soda added to the vinegar)*
   - *wearing of safety glasses*

6. Did the limewater become milky when the gas produced by the seltzer and water was tested for carbon dioxide?

   Yes, it should have, as carbon dioxide was produced.

7. Did the limewater become milky when the gas produced by vinegar and baking soda was tested for carbon dioxide?

   Yes, the limewater did become milky.

8. Was the gas produced in either or both of these reactions carbon dioxide?

   Carbon dioxide was produced in both reactions, as indicated by the limewater becoming milky in both instances.

Section 2: Activity 3

The following materials are needed for this activity:

- limewater (a few drops)
- cobalt (II) chloride paper (two or three strips)
- candle, about 10 cm high
- glass plate or square of thick aluminum foil
- two large glass jars
- matches

Students will have to prepare limewater, as before, from calcium hydroxide.

1. What is the purpose of the limewater in this investigation?

   Limewater is used to test for carbon dioxide.

2. What is the purpose of the cobalt (II) chloride paper in this investigation?

   The cobalt (II) chloride paper is used to test for water.

3. Why should you never leave an open flame unattended?

   You should never have an open flame unattended because something may catch on fire when you are not watching. Answers may vary.

4. Answer question 1 of Analysis.

   The following factors may be listed as indicators of a chemical reaction: heat or light is given off, the change is difficult to reverse, a gas was formed, and two new substances were formed.

5. Answer question 2 of Analysis.

   Textbook question 2. (a):

   Water droplets formed on the side. This can be proved with the cobalt (II) chloride paper. Black soot may have formed on the glass as well.

   Textbook question 2. (b):

   Carbon dioxide is formed by the candle. The drops of limewater turned milky.

Section 2: Activity 4

1. What is the scientific meaning of energy?

   Energy is the ability to do work.

2. Define potential energy.

   Potential energy is energy which is stored.

3. How does chemical energy relate to potential energy?

   Chemical energy is a form of potential energy.

4. Which word describes a chemical reaction in which energy is released?

   ***Exothermic** describes an energy-releasing reaction.*

5. Which word describes a chemical reaction in which energy must be supplied?

   ***Endothermic** describes a reaction that uses energy.*

6. Why do some chemical reactions need to have energy added to them?

   The products of the reaction contain more stored (potential) energy than the reactants. The additional energy must be absorbed during the reaction, or outside energy is needed to get some reactions started, but once underway, the reactions supply their own energy

Section 2: Follow-up Activities

Extra Help

1. Refer to page 39 of your textbook. Do Checkpoint questions 1 and 2.

   Textbook question 1:

   There are five clues to consider when deciding whether a change is physical or chemical. The presence of any of the five clues may suggest a chemical change.

   - *new colour appears*
   - *heat or light is given off*
   - *bubbles of gas are formed*
   - *solid material (precipitate) forms*
   - *change is difficult to reverse*

Textbook question 2. (a):

This is a chemical change. It is not reversible, gas is produced, and new chemicals and odours are produced.

Textbook question 2. (b):

This is a physical change. No new substances are formed and the change can be reversed, although a chemical change may follow at a later time.

Textbook question 2. (c):

This is a physical change. No new substances are formed and the process is difficult to reverse.

Textbook question 2. (d):

This is a chemical change. New substances are formed, heat and light are produced, and the reaction is difficult to reverse.

Textbook question 2. (e):

This is a chemical change. The colour change suggests that a new substance is formed.

Textbook question 2. (f):

Making tea is a physical change. No new substances are formed, the tea is just made into a solution.

Textbook question 2. (g):

Bleaching is a chemical change. The colour change indicates that a new substance is formed.

Textbook question 2. (h):

This is a physical change. No new substance is formed.

Enrichment

Students may do either Part A or Part B, or both.

1. Which pairs of chemicals underwent a chemical change? Explain your answer.

   Answers will vary, but any of the following clues may be listed:
   - *new colour appears*
   - *heat or light is given off*
   - *bubbles of gas are formed*
   - *solid material (precipitate) forms*
   - *change is difficult to reverse*

2. Refer to page 34 of your textbook. Do question 2 of Further Analysis.

   carbon dioxide + calcium hydroxide → calcium carbonate + water

3. Refer to page 36 of your textbook. Do question 5 of Further Analysis.

   sulphur + oxygen → sulphur dioxide

Section 2 Assignment

Marking Guide: Suggested values are given in brackets.

1. Refer to page 26 of your textbook. Do Further Analysis question 7, omitting part 7. (c). (2 marks for each part of the question – 1 mark for the type of change and 0.5 mark for each of two reasons in each case. Total of 14 marks.)

   Textbook question 7. (a):

   This is a physical change. There is no colour change, no bubbles or gas are produced, and the change reverses easily. The change is a result of a change of state.

   Textbook question 7. (b):

   This is a chemical change. Heat and light are given off and the change is not easily reversed.

   Textbook question 7. (d):

   This is a chemical change. The process is not easily reversed and slight heat is produced.

   Textbook question 7. (e):

   This is a chemical change. Heat, light, and gas are produced. The reaction is not reversible.

   Textbook question 7. (f):

   This is a physical change, eventhough glowing is actually a colour change. The process is reversible and no gas is given off.

   Textbook question 7. (g):

   This is a chemical change. The colour change, which is not reversible, indicates that a new substance is formed.

Textbook question 7. (h):

This is a physical change. No new substance is formed and the colour change is just a blend of the two.

2. Based on this information, what gas was present in the exhaust gas? (1 mark)

   Carbon dioxide was present in the exhaust gas.

3. What is the evidence of a chemical reaction between the aluminum foil and the liquid? (1 mark)

   Gas bubbles and a new substance were formed.

4. What gas was produced? (1 mark)

   Hydrogen was produced.

5. In terms of energy, what type of reaction was taking place between the aluminum foil and the liquid? Explain your answer. (2 marks)

   An endothermic reaction took place. The cooling of the liquid indicated that energy was consumed by the reaction.

6. In terms of energy, what type of reaction occurred during the test for the gas? (1 mark)

   An exothermic reaction took place.

Section 3: Acids and Bases

In this section students learn to recognize the hazards and safety procedures involved in the use of acids and bases. By the end of this section they will be able to describe the effects of acid-base reactions, and describe the effects of acids and bases on other materials as well. Students measure the strength of acids and bases on the pH scale with various indicators and identify the presence of acids and bases in household products.

Section 3: Activity 1

The following materials are needed for this activity:

- six small test tubes
- 12 mL of dilute hydrochloric acid
- 12 mL of dilute sodium hydroxide
- at least twelve strips of red litmus paper strips
- at least twelve strips of blue litmus paper strips
- 10 mL of phenolphthalein
- 10 mL bromthymol blue
- safety glasses
- test tube rack or other support
- student-selected samples of household chemicals
- a stirring rod

Students should avoid using household ammonia as a sample which is to be tested for acidity unless you dilute it by adding at least nine parts water to one part ammonia.

1. What is one significant difference between acids and bases that can be determined by taste?

   Acids taste sour and bases taste bitter.

2. If you were given a sauce called "sweet and sour sauce", do you think that this sauce would be an acid or a base?

   It would be an acid, since acids are sour.

3. What are substances that are neither acids nor bases called?

   They are neutral.

4. What do you call a substance that can be used to test for acids and bases?

   An indicator tests for acidity. An indicator is a different colour in an acid than it is in a base.

5. Identify the meaning of the acronym WHMIS.

   WHMIS stands for Workplace Hazardous Materials Information System.

6. What do the following WHMIS symbols mean ?

a.

This label indicates corrosive materials.

b.

This label is used to indicate poisonous and infectious materials that cause immediate and serious toxic effects.

7. What colour did the red litmus turn in water?

   The red litmus stayed red in water.

8. What colour did the red litmus turn in dilute hydrochloric acid?

   The red litmus stayed red in dilute hydrochloric acid.

9. What colour did the red litmus turn in the dilute sodium hydroxide solution?

   The red litmus turned blue in dilute sodium hydroxide solution.

10. What colour did the blue litmus turn in water?

    The blue litmus stayed blue in water.

11. What colour did the blue litmus turn in dilute hydrochloric acid?

    The blue litmus turned red in dilute hydrochloric acid.

12. What colour did the blue litmus turn in the dilute sodium hydroxide solution?

    The blue litmus stayed blue in the dilute sodium hydroxide solution.

13. What colour did the phenolphthalein turn in water?

    The phenolphthalein remained colourless (clear) in water.

14. What colour did the phenolphthalein turn in dilute hydrochloric acid?

    The phenolphthalein remained colourless in dilute hydrochloric acid.

15. What colour did the phenolphthalein turn in the dilute sodium hydroxide solution?

    The phenolphthalein turned pink in the dilute sodium hydroxide solution.

16. What colour did the bromthymol blue turn in water?

    The bromthymol blue remained blue or turned green in water.

17. What colour did the bromthymol blue turn in dilute hydrochloric acid?

    The bromthymol blue turned yellow in dilute hydrochloric acid.

18. What colour did the bromthymol blue turn in the dilute sodium hydroxide solution?

    The bromthymol blue remained blue when placed in the dilute sodium hydroxide solution.

19. Which of the materials that you tested were neither acidic nor basic?

    Answers will vary, but salt water, river water, and milk should test as neutral.

20. Complete the following chart.

<table>
<tr><th colspan="2">Foods</th><th colspan="2">Non-foods</th></tr>
<tr><th>Acidic</th><th>Basic</th><th>Acidic</th><th>Basic</th></tr>
<tr><td colspan="4">Answers will vary, but many food substances will turn out to be acidic and many home cleaning solutions will turn out to be basic.</td></tr>
</table>

21. Answer question 3 of Analysis.

    Answers will vary, but generally many food substances will turn out to be acidic and many home cleaning solutions will turn out to be basic.

22. Answer question 4 of Further Analysis.

    Textbook question 4. (a):

    Water is the control.

    Textbook question 4. (b):

    The control allows you to tell the starting point colour and, therefore, tell whether a change has taken place.

Section 3: Activity 2

The following materials are need for this activity:

- safety glasses
- 2 mL of dilute hydrochloric acid
- 2 mL of dilute sodium hydroxide
- six small test tubes
- a test tube rack or other support
- universal indicator paper (about twenty-four strips)
- student-selected samples of household chemicals
- a stirring rod

1. What is the scale for measuring acidity?

   The pH scale is used to measure acidity.

2. What is the pH range for acids?

   A pH of less than 7 indicates an acid.

3. What is the pH range for bases?

   Bases have a pH of greater than 7.

4. Why is universal indicator more useful than litmus paper?

   Universal indicator helps you determine the relative strength of different acids and bases. Litmus paper indicates only whether a substance is an acid or base.

5. Fill in the following chart with your data.

<table>
<tr><th>Food</th><th>pH</th><th>Non-food</th><th>pH</th></tr>
<tr><td colspan="2" rowspan="2">Most foods have pH below 7, but answers will vary.</td><td>hydrochloric acid solution</td><td>1 or 2</td></tr>
<tr><td>sodium hydroxide solution</td><td>11 or 12</td></tr>
<tr><td colspan="2"></td><td colspan="2">Most non-foods such as cleaning solutions will have a pH greater than 7, but answers will vary.</td></tr>
</table>

6. Was the universal indicator any more useful in classifying materials that initially appeared to be neither acidic nor basic? Explain your answer.

   Answers will vary. The following is a sample of a common answer. Yes , the universal indicator helped determine pH in the 5 to 7 range with more certainty. Weak acids and weak bases are more readily determined. Also, if the substance was coloured, universal indicator works better than drops of indicator.

Section 3: Activity 3

The following materials are needed this activity:

- safety glasses
- dilute hydrochloric acid (a few millilitres)
- baking soda
- bromthymol blue (a few millilitres)
- a stirring rod
- a beaker
- antacid tablets
- a 5 mL spoon or teaspoon
- mortar and pestle or a spoon and small dish
- a medicine dropper
- test tubes

1. What is the name given to the reaction of an acid and a base?

   The reaction of an acid and a base is called a ***neutralization reaction.***

2. Is a chemical reaction being used in the clean-up?

   Yes, the clean-up uses a chemical reaction.

3. What kind of chemical reaction is being used?

   A neutralization reaction is used.

4. Why not use a strong base for the clean-up?

   A strong base is also corrosive and it could also do some damage, instead of helping the situation.

5. Is a chemical reaction being used to clean the acid off your skin?

   Washing with cold water does not involve a chemical reaction. All you are doing is diluting the acid with water.

6. Why do you think that this strategy is used?

   You only use water because you do not want to have your skin damaged from both the acid and the base.

7. Why do you think that the problem for this activity compares the strength of an antacid tablet with baking soda?

   The baking soda can be measured out carefully. It also acts to neutralize the acid.

8. How many drops of acid are needed to neutralize 5 mL of baking soda solution?

   Answers will vary, but could be as much as 100 drops (5 mL).

9. Write out your plan to test the antacid tablet.

   Answers will vary. Each plan should include the following steps:

   - *add a few drops of indicator to the antacid solution*
   - *add dilute hydrochloric acid one drop at a time*
   - *count the number of drops required to bring about a colour change*

10. How many drops of acid are needed to neutralize 5 mL of antacid solution?

    Answers will vary. Generally, the number will be less than required for the baking soda solution.

11. Which required more acid to neutralize it, the baking soda solution or the antacid solution?

    Answers will vary, but most likely the baking soda took more acid for neutralization.

12. Answer question 1. (a) of Analysis.

    The colour of the indicator is different in an acid than in a base. Once the mixture has changed from being basic to being acidic, then the colour change of the solution will occur.

Section 3: Follow-up Activities

Extra Help

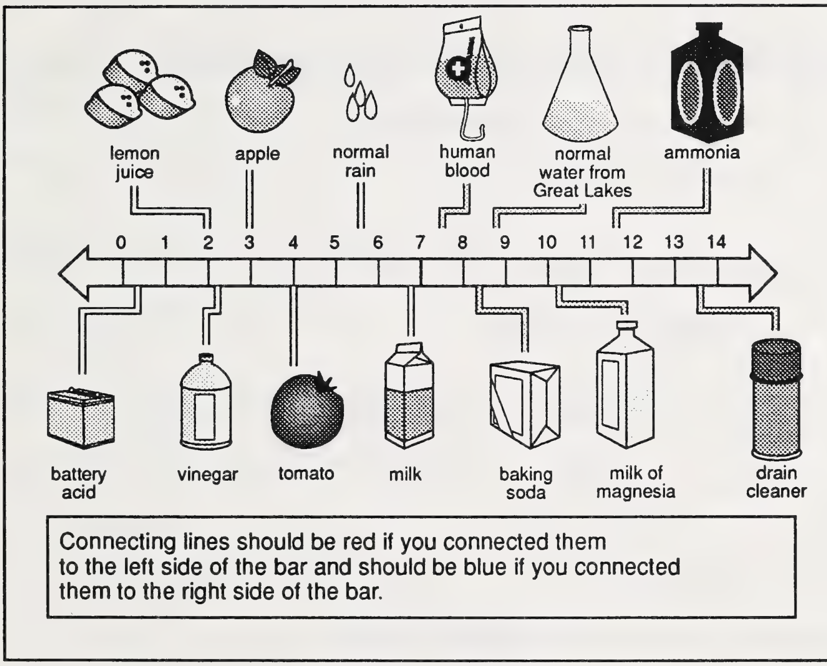
1. Complete the following chart.

Property	Acid	Base
Taste	*sour*	*bitter*
Touch	not described	*slippery*
pH Range	*0 – 7*	*7 – 14*
Reaction with Red Litmus	no change stays red	*becomes blue*
Reaction with Blue Litmus	*becomes red*	no change stays blue
Reaction with Base	neutralization	none
Reaction with Acid	none	*neutralization*

2. Complete the following general word equation.

acid + base → ___*water*___ + salt

3. On the bar below, colour the acid end red and the base end blue. Then connect the household products shown to their approximate pH value on the bar. If the product is an acid, use a red line. If the product is a base, use a blue line.



Enrichment

1. What do you think is the name of the gas which is produced in the reaction of a metal and an acid?

   Hydrogen is produced.

2. Complete the following word equations involving acid and metal reactions.

   a. hydrochloric acid + zinc → *hydrogen* + *zinc chloride*

   b. nitric acid + *zinc* → *hydrogen* + zinc nitrate

   c. *hydrochloric acid* + aluminum → *hydrogen* + aluminum chloride

d. acetic acid + magnesium → *hydrogen* + *magnesium acetate*

e. *acetic acid* + *iron* → hydrogen + iron acetate

3. Complete the following word equations involving neutralization reactions.

a. hydrochloric acid + sodium hydroxide → *water* + sodium *chloride*

b. sulphurous acid + calcium *hydroxide* → *water* + *calcium* sulphite

c. nitric acid + *sodium* hydroxide → *water* + sodium *nitrate*

Section 3 Assignment

Marking Guide: Suggested values are given in brackets.

1. Refer to page 41 of your textbook. Do questions 6 and 7 of Further Analysis.

Textbook question 6: (3 marks)

The blue litmus paper can be treated with acid. Answers may include dipping the paper in acid or putting the paper in acid fumes.

Textbook question 7: (2 marks)

The juice of the blueberries must be an acid-base indicator.

2. How can you tell if this juice is an acid or a base by its taste? (1 mark)

If it is bitter, then it is basic; if it tastes sour, then it must be acidic.

3. What scale should you use to measure how acidic or how basic the juice is? (1 mark)

The pH scale should be used.

4. Which type of indicator should you use if you wanted to find out the precise level of acid or base in the juice? (1 mark)

   You should use universal indicator.

5. If the pH level of this juice is 4.8, would you say that this juice is a stronger acid or a weaker acid than tomato juice? (1 mark)

   This juice is not as acidic as tomato juice, since it has a higher pH value.

6. What would you state as the problem? (1 mark)

   How does the borax solution compare with a baking soda solution?

7. Make a list of ten essential materials that you would require. (5 marks)

   Any ten of the following materials may be listed:

   - *safety glasses*
   - *water*
   - *borax solution*
   - *baking soda*
   - *dilute hydrochloric acid*
   - *indicator solution (phenolphthalein or bromthymol blue)*
   - *test tubes*
   - *test tube rack*
   - *100 mL beaker*
   - *teaspoon or 5 mL spoon*
   - *graduated cylinder*

8. What is the name of the reaction you would use for this experiment? (1 mark)

   A neutralization reaction should be used for this experiment.

9. Briefly write the procedure you would use for this experiment. (4 marks)

   Answers will vary. Each plan should include the following steps:

   - *Add a few drops of indicator to the baking soda solution.*
   - *Add dilute hydrochloric acid one drop at time.*
   - *Count the number of drops required to bring about a colour change.*
   - *Repeat the same steps for the borax solution.*
   - *Compare the number of drops required for each reaction.*

10. If you would have actually done the experiment, you would have obtained some results. Use the word list provided to identify what you would know about each of the following. Some words may be used more than once, some may not be used at all. (5 marks)

number of millilitres	equivalence
number of drops	not recorded
number of grams	not used

   a. dilute hydrochloric acid

      number of drops

   b. dilute sodium hydroxide solution

      not used

   c. baking soda

      equivalence or number of grams

   d. borax solution

      number of drops

   e. water

      number of millilitres

Section 4: Controlling Chemical Reactions

Science inquiry skills are developed in this section. Students predict and describe the effects of changing the concentration of materials, the particle size, and the temperature of the reaction on the rates of reaction. Through experimentation, the reaction rates are examined for the potential dangers of explosive reactions. Scientific inquiry skills are also used as students evaluate methods of controlling oxidation and corrosion reactions.

Section 4: Activity 1

The following materials are needed for this activity:

- four seltzer tablets
- a 250 mL beaker
- ice
- hot water (from a kettle or from tap)
- a thermometer
- a watch with seconds display
- two pieces of chalk
- about 40 mL of dilute hydrochloric acid
- two test tubes
- graduated cylinder
- file or serrated knife

1. What is the problem?

   How does temperature affect reaction rate?

2. What is the manipulated variable in this investigation?

   Temperature is the manipulated variable.

3. What is the responding variable in this investigation?

   Rate of the reaction is the responding variable.

4. Do step 1 of the procedure.

   (Students put the headings above the columns in the chart as part of step 1. The data belongs to question 5.)

   The chart is shown on the next page.

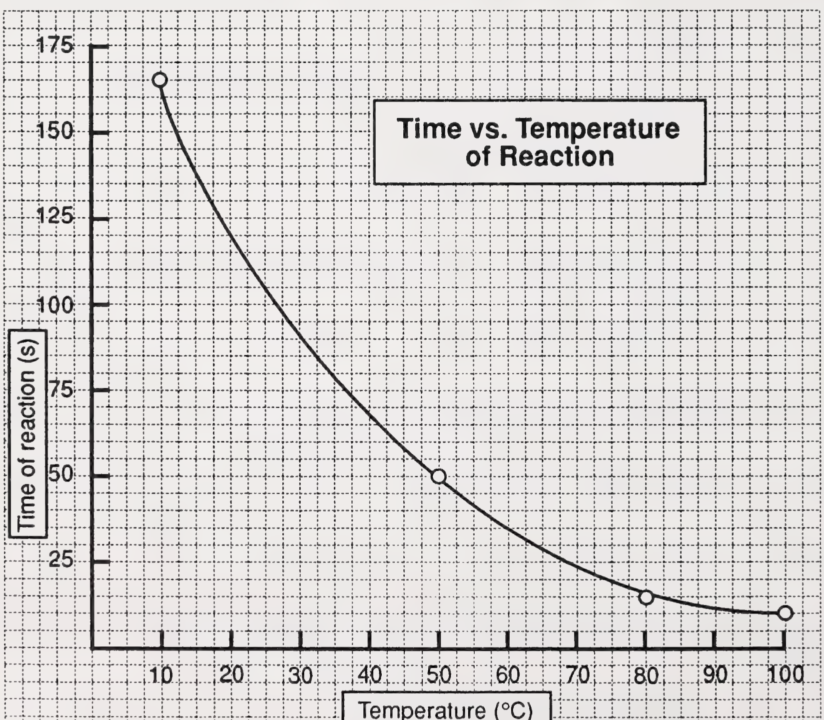
Temperature (°C)	*Time of Reaction (s)*
values vary	
0 – 10	*160 – 180*
15 – 25	*80 – 140*
30 – 50	*20 – 70*
80 – 100	*5 – 20*

5. Record your data in the table you prepared in question 4.

   See the suggested values in the previous chart. Student answers will vary.

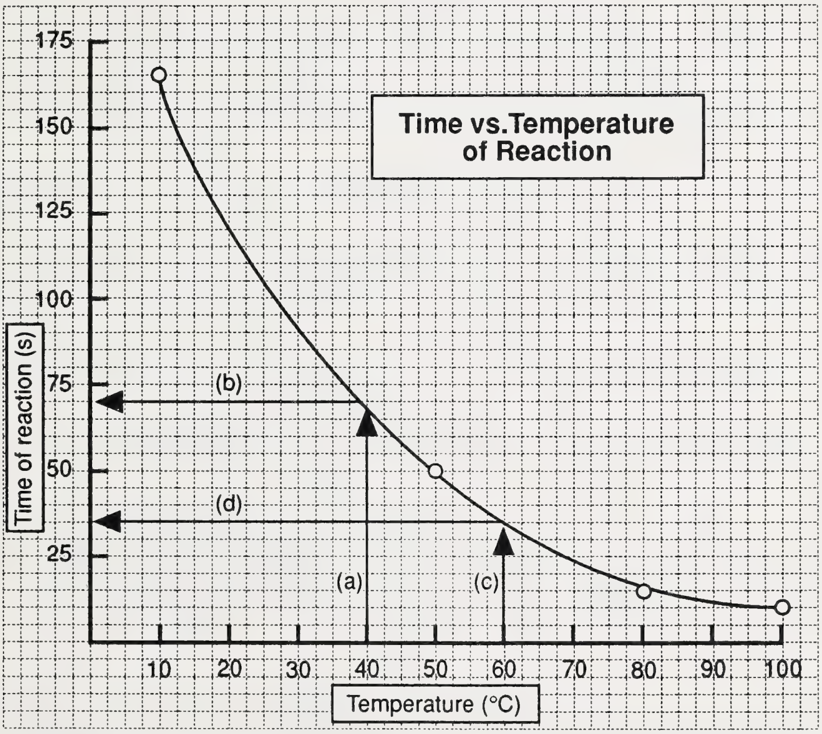
6. Do question 4. (a) of Further Analysis. Use the following grid to plot your graph.

   Check to see that the students graph matches the values the student gave in the previous chart. A sample graph is shown here.



7. Answer question 4. (b) of Further Analysis.

Student answers will vary. From this sample graph, it would take about 70 s at 40°C and 35 s at 60°C for a similar reaction.



You can check answers on students' graphs by following arrows (a) and (b) for 40°C and arrows (c) and (d) for 60°C. It is important that you are checking the students' skills, not the exact numbers, as the data may vary considerably from one student to another.

8. Answer question 5 of Further Analysis.

You would expect that the values (points) on the graph would be different. You would expect the shapes of the graphs would be the same.

9. Complete questions 1 to 4 of Predicting.

   Textbook question 1: (a):

   The total surface area of the block is 24 cm^2.

   Calculations: surface area = $6s^2$ $s = 2$
   $6 \times 2 \times 2 = 24$

   Textbook question 1: (b):

   The total surface area of the block is now 48 cm^2.

   Calculations: surface area = $6s^2$ $s = 1$
   Now there are eight individual blocks, so the surface area of one block must be multiplied by 8.
   $8 \times 6 \times 1 \times 1 = 48$

   Textbook question 2:

   The surface area increases if a large piece of solid is broken into smaller pieces.

   Textbook question 3:

   The greater the surface area, the greater the area in contact, therefore, the faster the reaction. Since this is a prediction, other reasonable answers are not considered incorrect.

   Textbook question 4:

   Smaller sticks have a greater surface area and therefore burn more quickly. That is why small sticks are used for starting fires.

10. Define *concentration* in your own words.

    Concentration refers to the amount of material that is dissolved in a solvent.

11. Make a prediction about how the rate of the reaction may be affected by the concentration.

    The greater the concentration, the greater the amount of chemical, so the reaction rate should be faster. Since this is a prediction, answers should not be considered incorrect.

12. State the problem.

    What is the effect of the surface area on the rate of the reaction?

13. Predict what you think will be the effect of the particle size on the rate of the reaction.

    The larger the particle, the slower the reaction rate will be because there is less surface area. Smaller particles have more surface area so the reaction rate should increase.

14. What is the manipulated variable in this investigation?

    The manipulated variable is the particle size or surface area. Students may answer either way.

15. What is the responding variable in this investigation?

    The responding variable is the rate of the reaction or the time the reaction takes. Students may answer either way.

16. Write out your stepwise procedure for investigating this manipulated variable.

    Answers will vary, but the general technique should include the following steps:

    - *Start with one complete piece of white chalk and cut it in half with a file or serrated knife.*
    - *Leave one half of chalk as a single piece.*
    - *Grind up the second half of chalk with a mortar and pestle (or spoon).*
    - *Place equal amounts of the two forms of chalk into two test tubes.*
    - *Then add equal amounts of dilute hydrochloric acid and observe the rate of the reaction.*

17. In the following space, prepare a table in which you will record your data. You will make qualitative descriptions that can include words like *fast*, *slow*, *very fast*, and *very slow*.

Size of Chalk	*Rate of Reaction*
whole piece	*slow*
crushed piece	*fast*

18. Write a concluding statement which answers the question that was asked in the problem. Comment on the validity (correctness) of your initial prediction.

    The crushed chalk reacted much faster than the whole piece. Students will comment whether their predictions were correct or incorrect.

19. Give an example of a practical application of the knowledge gained from this experiment.

    Answers will vary. Practical applications may include the following: kindling wood burns faster than a log; steel wool rusts faster than a steel bar; sliced potatoes cook faster than whole potatoes.

20. State the problem.

    What is the effect of the acid concentration on the rate of the reaction?

21. Predict what you think will be the effect of the concentration on the rate of the reaction.

    The greater the concentration of the acid, the faster the reaction.

22. What is the manipulated variable in this investigation?

    The concentration of the acid is the manipulated variable.

23. What is the responding variable in this investigation?

    The rate of the reaction or time of the reaction are responding variables. Either answer is correct.

24. Write out your stepwise procedure for investigating this manipulated variable.

    Answers will vary, but the general technique should include the following steps:

    - *Start with one complete piece of white chalk and cut it in half with a file or serrated knife.*
    - *Grind up each piece of chalk with a mortar and pestle (or spoon and dish).*
    - *Place equal amounts of chalk into two test tubes.*
    - *Make up a hydrochloric acid solution called "double dilute".*
    - *To begin the reaction, add equal amounts of dilute hydrochloric acid to one of the test tubes containing powdered chalk, and double dilute hydrochloric acid to the other.*
    - *Observe the reaction rates.*

25. In the following space, prepare a table in which you will record your data. You will make qualitative descriptions that can include words like *fast*, *slow*, *very fast*, and *very slow*.

Concentration of Acid	*Rate of the Reaction*
dilute	*fast*
double dilute	*slow or very slow*

26. Write a concluding statement which answers the question that was asked in the problem. Comment on the validity (correctness) of your initial prediction.

The rate of the reaction decreases when you increase the dilution of the acid. The rate of the reaction increases when the acid concentration is stronger. Students will comment whether their prediction was correct or incorrect. Answers will vary.

27. Give an example of a practical application of the knowledge gained from this experiment.

Student answers will vary. An example may be that stronger acid solution will work to clean the swimming pool faster than a weak solution.

28. Answer question 3 of Analysis.

The test tube will feel warmer, so heat must have been given off. Therefore, the reaction is exothermic.

29. Answer question 7 of Further Analysis.

The reaction should go faster if the reactants are warmed up.

Section 4: Activity 2

The video *Chemistry in Everyday Life* has been incorporated into this activity as an option for students to view some practiced applications of chemistry in everyday life.

The following materials are needed for this activity:

- steel wool
- four one-hole stoppers with glass tubing (or rigid plastic tubing) inserted in each
  The glass tubing should be about 12 cm long and should extend about 2 cm beyond the narrow end of the stopper. The stoppers should fit the test tubes being used.

- four test tubes of the same size
- food colouring (optional)
- four cups or other containers, or one large container
- test tube holder or other support
- various rust-proofing test materials (eg., oil, wax, paint, salt water)
- safety glasses

The students should be supplied with stoppers with the glass tubing (or rigid plastic tubing) already inserted. If you do allow students to insert glass tubing themselves, make sure short pieces of tubing are involved and that the ends of the tubes are smooth (have been fire polished). Make sure that students wear work gloves. The tubing should be lubricated (with a bit of cooking oil) and should be inserted with gentle pressure. The tubing should be rotated as it is inserted. Supervise this procedure closely.

1. Take a look around your home or school and find three examples of metal corrosion.

   Answers will vary. Some answers may include rust on metal fences, cars, or on the chains of bicycles; or discolouration of the cement near the eaves trough.

2. What is the manipulated variable in this investigation?

   The manipulated variable is the treatment of the steel wool or the corrosion-proofing method. Answers will vary.

3. What is the responding variable in this investigation?

   The responding variable is the rate of rusting or corrosion.

4. List the rust treatments that you are going to investigate.

   Answers will vary. These could include painting, dipping in paint, dipping in oil, dipping in wax, dipping in vinegar, spraying with silicon spray, and spraying with penetrating solution.

5. Predict which treatment you think will provide the best rust protection.

   Answers will vary depending on the student's choice of rust treatment. Spray painting may be found to be most effective.

6. What type of data are you collecting? Circle the correct word.

   quantitative　　　*qualitative*

7. In the space provided, prepare a table to collect the data for a 3-day period.

   Answers will vary. A sample answer is shown in the table.

Rust Protection	***Height of the Water (cm)***
steel wool no treatment	*8*
steel wool oiled	*4*
steel wool painted	*2*
steel wool wax dip	*2*

8. Write a concluding statement which answers the question that was asked in the problem. Also comment on the validity (correctness) of your initial prediction.

   Answers will vary. The best rust-proofing method is painting. The students should comment whether their prediction was correct or incorrect.

9. Give an example of a possible practical application of the knowledge gained from this experiment.

   Cars are painted, working parts are oiled, etc.. Answers will vary.

10. Refer to the three examples of corrosion which you listed in question 1. Suggest how you would prevent or slow down their corrosion.

    Answers will vary depending on the examples listed in question 1. (For example, the chain of a bicycle may be oiled to prevent rusting and rust spots on the cars can be sanded off and repainted.)

11. Give a practical application of chemistry that is important to you and explain how you personally benefit from this application.

    Answers will vary. (The applications need not come from the video). Students may list some of the following:

    - *rayon in their blouses or shirts*
    - *paint on their bedroom walls or on their bicycles*
    - *medicine for colds or other diseases*
    - *plastic components of roller blades*

Section 4: Follow-up Activities

Extra Help

1. What would be the manipulated variable in this example?

   The size of the magnesium pieces is the manipulated variable.

2. What would be the responding variable in this example?

   The rate of the reaction is the responding variable.

3. Write out a problem statement for where the concentration of the hydrochloric acid is the manipulated variable and the reaction rate is the responding variable.

   The problem can be written as follows: What is the effect of the concentration of hydrochloric acid on the rate of the reaction?

4. Use the same graph to predict how much time the reaction would take if the acid strength was 5 c.

   It would take about 80 seconds. This value is read from the graph.

5. Use the same graph as before to extrapolate how much time the reaction would take if you had an acid strength of 14 c.

   The reaction would take 20 seconds.

6. Refer to page 55 of your textbook. Do Checkpoint question 5. Be sure that your explanations are backed up by the major points that you have learned about reaction rates, temperature, and surface area.

   Textbook question 5. (a):

   A heated garage will speed up the rusting process because reaction rates are faster as the temperature increases.

   Textbook question 5. (b):

   Washing the car will remove the salt, or at least will dilute the salt concentration. Therefore the rusting reaction will proceed much slower.

Textbook question 5. (c):

Rubber mats will help the floor stay dry and prevent rust from starting on the inside of the car.

Textbook question 5. (d):

Painting over the areas where the paint is chipped will keep the metal from being exposed. This will prevent the rusting process.

Enrichment

Write a brief report which could be used by consumers who are making a decision about rust proofing a new vehicle.

This is a very open question. Student answers will vary greatly. There are at least two major companies working in the rust-proofing business in the cities. Costs can run from about $150 to $450, depending on the coverage. Some treatments include spraying a thick-oil-based sludge into all the rocker panels of vehicles. This prevents the moisture from getting in and causing rusting from the inside. Other treatments also put a polymer chemical over the paint to prevent oxidation.

Section 4 Assignment

Marking Guide: Suggested values are given in brackets.

1. Refer to page 53 of your textbook. Do question 3 of Further Analysis.

   Textbook question 3. (a): (2 marks)

   Steel wool has a greater surface area than steel nails. Therefore, the steel wool should rust faster.

   Textbook question 3. (b): (2 marks)

   Vancouver is both warmer and more moist. Both these factors should make a bike rust faster in Vancouver.

2. How many candies do you think they used in each of the trials shown in the chart on the following response page? Complete the chart. (3 marks)

Number of Candies	Time of Reaction
5	25
15	75
10	50
20	100
1	5

3. What was the manipulated variable in this experiment? (1 mark)

   The manipulated variable was the number of candies.

4. What was the responding variable in this experiment? (1 mark)

   The responding variable was the time of the reaction.

5. State the problem that the students should have written into their notebooks. (2 marks)

   How does the number of candies affect the time (rate) of the reaction?

6. Extrapolate or estimate the "fizz time" for twenty-five candies. (1 mark)

   The "fizz time" for twenty-five candies is 125 seconds.

7. What is a variable that must be kept constant, since it may also affect the time of the reaction? (1 mark)

   The temperature of the water, volume of the water, and size of the candy may be listed.

8. State the problem for investigating the variable that you listed in question 7. (2 marks)

   This answer must be in agreement with the answer listed in question 7.

Final Module Assignment

Marking Guide: Suggested values are given in brackets.

1. Classify each of the following changes as physical or chemical. Write the word **physical** or **chemical** for each. (5 marks)

   a. burning *chemical*
   b. breaking *physical*
   c. bubbles forming *chemical*
   d. boiling *physical*
   e. blue becomes red *chemical*

2. A student picked some purple flowers from the garden. The only container that could be found for the flowers was an old pickle jar. The jar had not been washed out very carefully and, an hour after the flowers were put in the jar, they turned pink. (Hint: Vinegar is used for making pickles.)

   a. Give a possible explanation for the change in colour. (1 mark)

      The flower colour changes from purple to pink in an acid.

   b. What kind of change (chemical or physical) took place inside the petals of the flowers? (1 mark)

      The change was chemical.

   c. Give a practical application of this colour change. (1 mark)

      This could be used as an acid/base indicator.

   d. What colour would these same flowers likely be if they were grown in soil that was alkaline (basic)? (1 mark)

      The flower would be purple.

   e. What colour would these flowers be if they were grown in an area that received a considerable amount of acid rain? (1 mark)

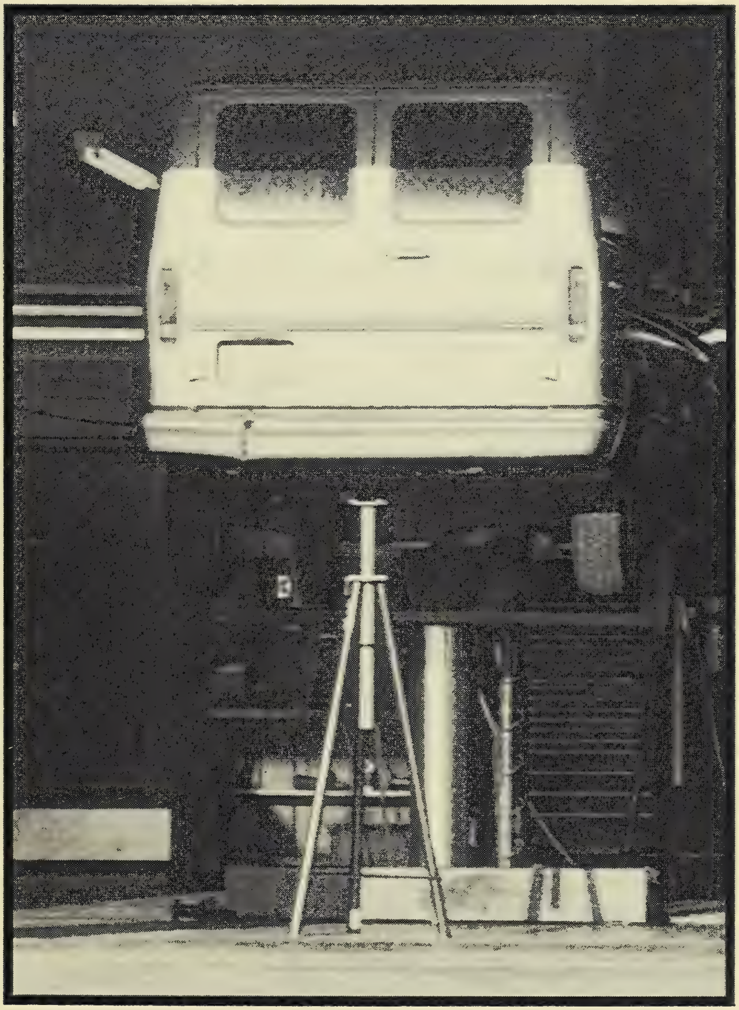
      The flower would be pink.

3. Imagine that you are given four unlabelled bottles of colourless liquids. You know that one bottle contains water, one contains dilute acid, one contains dilute base, and one contains salt water. You have access to blue and red litmus paper, test tubes, and a watch glass.

   Describe the tests that you would carry out to help identify each of these liquids. What would you consider to be the positive result for each of the tests? (10 marks)

   - *Blue litmus turns red in an acid. Acid is identified.*
   - *Red litmus turns blue in a base. Base is identified.*
   - *Red litmus does not change colour in acid, water, or salt water.*
   - *Blue litmus does not change colour in base, water, or salt water.*
   - *On evaporation, salt water leaves crystals behind; water does not. Water and salt water are identified.*

SCIENCE 9



Module 2

Fluids and Pressure

LEARNING FACILITATOR'S MANUAL

Distance Learning

Alberta
EDUCATION

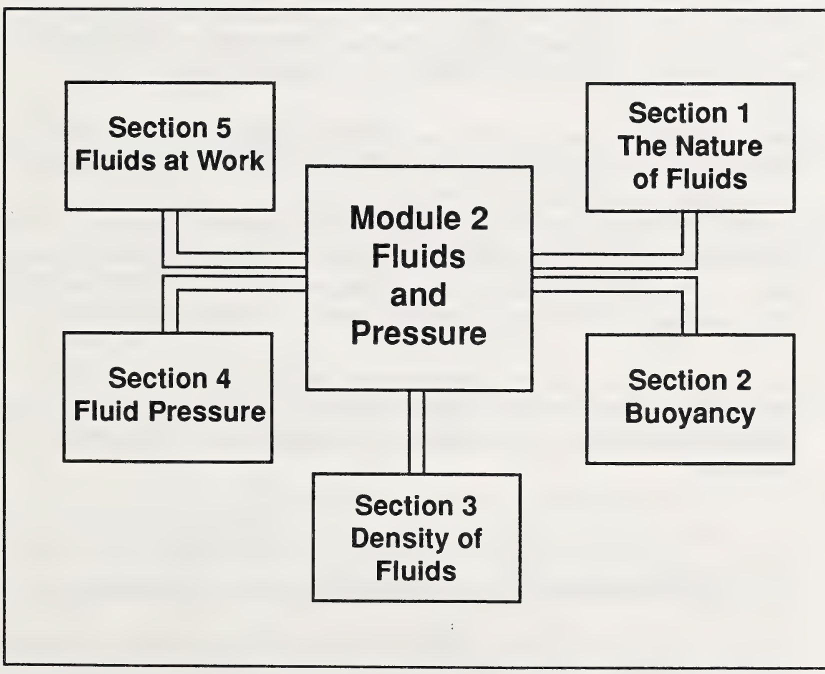
Module 2 – Fluids and Pressure: Overview

The major emphasis of this module is science and technology.

In this module the students will be learning about a group of materials called fluids. These include gases and liquids and are characterized by the ability to flow. The students will be doing activities that demonstrate that gases are fluids, that different fluids flow at different rates, and that temperature affects the rate of a fluid's flow.

The students will then learn about the force of buoyancy and the factors that determine the strength of buoyancy. Density and its relationship to the floating of objects in fluids is also dealt with.

Opportunities are provided in the module for the students to construct and make improvements to devices that will perform specific functions. The students will examine existing technologies and consider alternatives in their design.



Classroom Opener

Begin this module with a discussion about everyday sensations of fluid pressure. You may ask students if they ever feel their ears pop while travelling up and down mountain roads. This sensation is due to changes in air pressure that are caused by changes in altitude. Students may answer that pressure is also felt on the ears when they dive deep into a lake or pool. You could explain that drinking a milk shake through a straw is only possible because of the pressure of the atmosphere. Students should become impressed by the fact that the pressure exerted by fluids influences a wide variety of phenomena around them.

Materials and Equipment

The materials and equipment needed are listed under each activity. In planning for the acquisition of the required materials and equipment, you will find it useful to preview these lists.

Throughout this module, the use of modified syringes is required. They are described and illustrated on page 63 of *Science Directions 9*, the textbook for the course. The modified syringes do not have needles and are modified with platforms attached to the tops of the plungers (pistons). The modified syringes should be prepared in advance. Students will be asking for these.

The syringes should have tips of the same outside diameter, since they will be connected with tubing. Although 10 mL and 50 mL syringes are called for, the somewhat larger and more easily obtainable 12 mL and 60 mL syringes may be used.

Recommended syringes are the 12 mL and 60 mL luer-tipped Monoject™ syringes. These are available from local veterinarian clinics or medical home-care suppliers. Vinyl tubing from Northwest Laboratories Ltd. (catalogue #17-6360) with an inside diameter of 3.2 mm is suitable tubing to connect the syringes.

In the activities, loads will be placed on the platforms of the modified syringes. Instead of laboratory 1 kg masses, hardcover books of about the same mass and weight can be balanced on the platforms. A spring scale can be used to select appropriate books. For a 1 kg mass, a book weighting 10 N on a spring scale can be used.

For the platforms of the modified syringes, 10 cm square pieces of corrugated cardboard may be glued onto the plungers of the syringes. Large lids may also be attached. Be sure that a very strong glue is used. Before using the modified syringes, test the platforms to make sure that they are secure.

To support books on the plungers, flat cardboard platforms are suitable. For books, lids can also be attached label-side-up. To support 1 kg masses, lids should be attached label-side-down so that the rims keep the masses in place. Note that platforms are not essential to support books; however, platforms do make balancing the books easier.

Throughout this module, support stands and clamps would be helpful to support the modified syringes in an upright position; however, syringes can easily be held in place manually. If support stands are used, students may need to be told several times not to tighten the clamps too hard. The clamps can deform the syringes so that the pistons are difficult to move.

Students may need to be reminded to thoroughly clean and then lubricate the syringes between uses. Vegetable oil makes a suitable lubricant. The previously recommended syringes should not have isopropanol put in them. The alcohol ruins the plastic of these syringes and renders them unusable.

Evaluation

The mark in this module will be determined by students' work in the Assignment Booklet. Students must complete all assignments. In this module students are expected to complete five section assignments and a final module assignment.

The assignment breakdown is as follows:

Section 1 Assignment	**13%**
Section 2 Assignment	**12%**
Section 3 Assignment	**15%**
Section 4 Assignment	**20%**
Section 5 Assignment	**20%**
Final Module Assignment	**20%**
TOTAL	**100%**

Section 1: The Nature of Fluids

In this section the students will learn that gases and liquids are fluids, that gases and different liquids flow at different rates, that the rate at which fluids flow can be changed, and that movement through gases is easier than through liquids.

Section 1: Activity 1

Some easily obtainable materials, depending on the design of a demonstration to show that gases flow, are needed. For example, chalk dust, a flashlight, a piece of paper, and a straw may be needed.

1. Study picture (a) on page 60 of your textbook. How can the three people in the photograph tell that there is flowing water behind them?

   This question is designed to get the student to think of ways that things can be detected without seeing them. The people can tell that there is water flowing behind them by the sound of the water and possibly by the spray that they may feel from the rapids.

2. Study picture (b) on page 60 of your textbook. What sense does the child in the photograph use to tell him that the water is flowing?

   This question is similar to question 1. The child knows that water is flowing by the sound of flowing water and by the feel of the water spray on his skin.

3. Do step 2 of the procedure. Demonstrate to your learning facilitator that gases do flow. Describe your demonstration.

   The answer will depend on the activity developed by the student. Any activity where the movement of a gas, usually air, can be detected is sufficient.

   Sample description: I blew through a drinking straw and my facilitator could feel the force of the air.

4. What sense did you use to help show that gases flow? Explain your answer.

   The answer will depend on the activity developed by the student. The answer would probably be of the sense of touch, hearing, sight, or possibly smell. Most answers would depend on the effect of the invisible air on visible materials and on the non-visual senses.

   Sample answer: I used my sense of smell to detect the flow of the gas. The perfume gases flowed from the open bottle until I detected the smell with my nose.

5. What does the word *flow* mean?

   These answers will vary. The answer should reflect the movement along a continuous stream or something with a changing indefinite shape that applies a force when something is placed in its path.

   Sample answer: Flow occurs when a liquid or gas moves from one place to another without a container moving along with it.

6. Which states of matter flow?

   Liquids and gases are the states of matter that flow.

7. Use the particle theory to explain why liquids and gases flow, whereas solids do not.

   In liquids and gases, flow depends on the particles being able to move freely from place to place. Solids do not flow because the particles of the solid cannot move freely past each other.

Section 1: Activity 2

The following materials are needed for this activity:

- a 50 mL modified syringe
- a 250 mL beaker or other container
- a mass of about 1 kg. The textbook *Science Directions 9* may be used as a load.
- a timing device
- water

A support stand and two burette clamps can be used to support the modified syringe; however, another person can be used to hold the syringe in place manually over the beaker. Maybe you, as the learning facilitator, can help.

1. Complete the table with the times needed to empty the syringe.

   The times for the air-filled syringe should be less than those for the water-filled syringe. The air times will average about 1 second, for water they will vary from 3 to 7 seconds.

   The following chart contains sample data:

Fluid	Trial	Time (s)
Air	1	*1*
	2	*1*
	3	*2*
Water	1	*5*
	2	*6*
	3	*4*

2. Answer the first part of question 1 of Analysis on page 65.

   The piston in the air-filled syringe moved down faster than the piston in the water-filled syringe. Water flows more slowly than air.

Section 1: Activity 3

1. What everyday examples can you think of that also illustrate the fact that a gas is easier to move through than a liquid?

   It is easier to walk through air than through water. Airplanes and cars are able to travel much more quickly than boats and submarines. Any answer that shows that air flows more easily than water is acceptable.

2. There is a practical example described at the top of page 65 of your textbook. What is it and how does it make use of the information that you discovered in the previous activity?

   An object can move through air more easily than it can move through water. The previous investigation showed that air flows and can be pushed aside more easily than water. So a boat that is designed to go mostly through the air, like a hydrofoil, will be able to travel more easily and quickly than a boat that is designed to go through the water.

3. The word used to describe how fast or slow a fluid flows is ___*viscosity*___.

4. Make up a sentence that includes the word from question 3 and the names of two fluids. Make sure that the sentence illustrates how well you think the substances will flow when compared to each other.

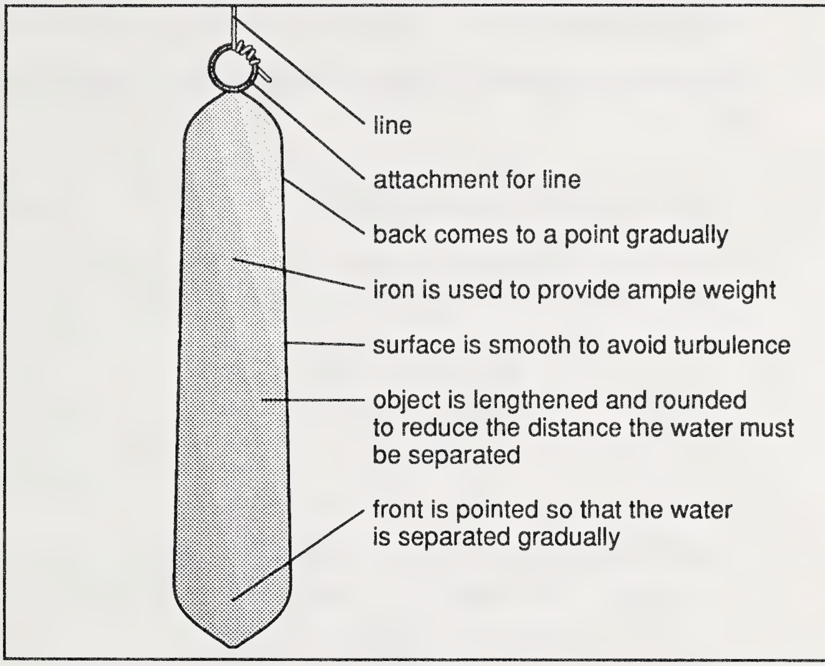
   Answers will vary, but they should be like the following example: Molasses flows more slowly than water because it has a higher viscosity.

5. How has the front of the new van been changed to allow the van to travel more easily through air?

   The front of the van has been slanted so that the air is pushed up and out of the way as the van moves. If the front is nearly straight up and down, the air builds up in front of the van and pushes back against it when it is moving. If the air is pushed upwards out of the way, there is less air resistance.

6. A sounder is a weight that is attached to a line and used to measure the depth of water. Design a sounder that will drop through water very easily. Sketch a picture of your design. Label the sketch to indicate how you would make it streamlined.

   Students should draw a weight with a streamlined shape. Students may make the back less dense than the front so that the weight has a greater tendency to drop straight down; however, that consideration is more than expected. A sample answer follows on the next page.



Section 1: Activity 4

The following materials are needed for this activity:

- a 50 mL modified syringe
- a 250 mL beaker or other container
- a mass of about 2 kg or two masses each having a mass of about 1 kg
- a timing device
- vegetable oil, water, and other liquids approved by you, the learning facilitator, for the testing of flow rate

A support stand and two burette clamps can be used to support the modified syringe; however, another person can hold the syringe in place manually.

The liquids you approve for use in this lab should not be volatile, highly flammable, or hazardous in any way. In addition, the use of alcohol (apart from glycerol) should be avoided with plastic syringes because the alcohol reacts with plastic in such a way that the syringe becomes unusable.

Books may be used as a load for the syringe. Two hard cover books, each weighing about 10 N (having a mass of 1 kg), can be balanced on the platform. A spring scale can be used to select the books.

Students may need some directions about disposal of the liquids used. Keep glycerol and vegetable oil for later activities.

1. What is the problem?

   The problem for this investigation may be stated as follows: Do different liquids flow at different rates?

2. Fill in the first and third columns in the table.

   The times will vary, depending on the liquids used and the temperature at which the activity is performed. Some sample times, liquids, and flow rates are shown in the chart.

Liquid	Volume (mL)	Time (s)
water	50	*3*
glycerol	50	*55*
isopropanol	50	*6*
vegetable oil	50	*7*

3. In the space provided, calculate the flow rate for each of the four liquids that you tested.

   Answers will vary, depending on the liquids used. The longer the time taken for the liquid to flow from the syringe, the lower the calculated flow rate should be. The following are sample calculations using the data presented in question 2.

$$\text{flow rate for water} = \frac{\text{volume}}{\text{time}} = \frac{50\ \text{mL}}{3\ \text{s}} = 17\ \text{mL/s}$$

$$\text{flow rate for glycerol} = \frac{\text{volume}}{\text{time}} = \frac{50\ \text{mL}}{55\ \text{s}} = 0.9\ \text{mL/s}$$

$$\text{flow rate for isopropanol} = \frac{\text{volume}}{\text{time}} = \frac{50\ \text{mL}}{6\ \text{s}} = 8.3\ \text{mL/s}$$

$$\text{flow rate for vegetable oil} = \frac{\text{volume}}{\text{time}} = \frac{50\ \text{mL}}{7\ \text{s}} = 7.1\ \text{mL/s}$$

4. Enter the flow rates that you calculated in the following table.

   The calculated results are to be filled in the table. Some sample values are provided, based on the data presented in questions 2 and 3.

Liquid	Volume (mL)	Flow Rate (mL/s)
water	50	*17*
glycerol	50	*0.9*
isopropanol	50	*8.3*
vegetable oil	50	*7.1*

5. In the following table, enter the substances in order from most viscous (most time to flow) to least viscous (least time to flow). Include your calculated flow rates.

   The answers will vary, depending on the liquids that were used. The following is a sample that corresponds to the results presented to you in question 4. The liquids are listed in order with the most viscous liquid (glycerol) being shown at the bottom of the chart and the least viscous liquid (water) being shown at the top of the chart.

Liquid	Flow Rate
water	*17* mL/s
isopropanol	*8.3* mL/s
vegetable oil	*7.1* mL/s
glycerol	*0.9* mL/s

Comment: For question 6, the textbook questions come from page 67.

6. Answer questions 6. (a) and (b) of Further Analysis on page 67.

   Textbook question 6. (a):

   Students should be familiar with the main points of the particle theory and use them to answer the question.
   Example: The particles in a liquid are free to move in all directions relative to each other. They are not held in fixed positions. There are weak attractive forces between the particles.

Textbook question 6. (b):

Students are to use the particle theory to explain their observations.

Example: Different liquids flow at different rates because the particles in different liquids are held together by attractive forces with different strengths. For example, the particles of syrup are attracted to each other more strongly than the particles of water. As a result, syrup flows more slowly than water.

7. When different liquids are to be moved through tubes and pipes, the viscosity of the liquids has to be considered in order to determine the size of tubes to be used. With this in mind, why are milk shake straws different from soft drink straws?

   The viscosity of a milk shake is greater than that of a soft drink. To compensate for the slower flow of the milk shake, the straw for the milk shake has a larger diameter.

8. If you assume that both pipelines carry the same amount of liquid, which one is the water pipeline, the larger one or the smaller one? Use what you have learned in this activity to explain your answer.

   The water pipeline will be the smaller pipeline because the viscosity of water is lower than that of oil. To accommodate the thicker oil, the oil pipeline must be made larger. This allows the same amount of fluid to be transported through both pipelines.

Section 1: Activity 5

The following materials are needed for this activity:

- a 50 mL modified syringe
- at least one 250 mL beaker or container
- a mass of about 2 kg or two masses each having a mass of about 1 kg
- a timing device
- a thermometer
- at least one large container (pot or a 600 mL beaker) for a water bath
- water
- vegetable oil (or corn syrup)
- ice cubes

A support stand and two burette clamps would be best, but the modified syringe can be held in place by another person. As before, hard-cover books can be used as a load for the syringe.

Corn syrup is a good substitute for vegetable oil in this activity. It is easy to clean up and its flow is dramatically affected by temperature. Vegetable oil should be saved for subsequent use in these activities. Corn syrup can be saved if you will be working through this activity with other students; otherwise, it can be put in an empty milk carton and disposed of in the garbage.

In this activity four samples of vegetable oil (or corn syrup) at different temperatures must be prepared. These samples are needed for four trials. If the samples are prepared individually for each trial, less of the fluid is required since the fluid can be reused. As well, then only one 250 mL beaker is needed for the samples and only one large container is needed for the water baths.

Students should do the heating under adult supervision. Observe the safe handling of the hot water and oil. Hot oil may spatter. Rinse all burns under cold running water for 15 minutes and see a doctor immediately.

1. What is the problem?

   The problem may be stated as follows: Does temperature affect the viscosity of a liquid?

2. Fill in the following table with your data.

   The results will depend on the actual liquid and temperatures used for the activity. The flow rate calculations are the same as in previous activities (Activity 4, question 3).

   Sample answers are shown in the chart.

Flow Rate and Temperature

Temperature (°C)	Volume (mL)	Time (s)	Flow Rate (mL/s)
0	50	*20*	*2.5*
20	50	*8*	*6.3*
40	50	*7*	*7.1*
60	50	*6*	*8.3*

3. What is the effect of different temperatures on the viscosity of vegetable oil?

   The heat causes the viscosity of the oil to decrease.

4. Use the particle theory to explain your results. (Remember what happens to particles when they are heated.)

   The particles move more quickly as the oil is heated. This motion will weaken the attractive forces between the oil particles, allowing the fluid to flow more easily. Its viscosity decreases.

5. In your own words, why is it important that the viscosity of liquids at different temperatures be known in Alberta?

   It is important that the viscosities of liquids at different temperatures be known in Alberta because of the many oil pipelines in the province. During the winter, the temperatures may reach – 40°C, and that makes the viscosity of oil very high. Then it is very difficult to pump. A solution would be to heat it and insulate the pipelines. The same goes for refineries and the tar sands in northern Alberta.

Section 1: Follow-up Activities

Extra Help

Fill in the blanks with the words from the list. Use each word only once.

quickly	decreases
fluids	liquids
temperature	flow
viscosity	gases
slower	low
high	

In this section you have been examining the types of matter called ______*fluids*______. They are substances that ______*flow*______, as water does in a river or through a hose. Fluids include both ______*liquids*______ and ______*gases*______.

Gases flow more ______*quickly*______ than liquids. For example, the flow of water is ______*slower*______ than the flow of air.

The speed that fluids flow at is called their ______*viscosity*______; ______*high*______ viscosity means that the fluid flows slowly, ______*low*______ viscosity means that the fluid flows quickly.

Finally you found that ___*temperature*___ has an effect on the viscosity of a liquid. As it is heated up, the viscosity ___*decreases*___. Keep in mind that you are not referring to the melting or freezing of a substance.

Enrichment

1. Explain in your own words why sand is not a fluid.

   Sand is not a fluid because it is made up of many tiny grains of solid material. As a result, it forms a mound as it is poured. A true fluid forms a flat surface when it is in a container.

2. Use the particle theory to explain why gases flow more freely than liquids.

   The distances between the particles of a gas are far greater than the distances between the particles of a liquid. The attractive forces between particles of gas are almost non-existent; they are weak but significant in a liquid. As a result, the particles in a gas can easily move past one another and flow. In a liquid the particles are less free to move and flow.

3. Sometimes it takes a long time to get syrup out of a bottle that is almost empty. Use what you learned in this section to explain how you could get syrup out of the bottle quickly.

   Using the results of one of their activities, students can heat the bottle to lower the viscosity of the syrup remaining in the bottle, making it easier to pour.

4. Classify the following substances as fluids or non-fluids. Give reasons for your answers.

   Answers should be assessed on the reasons given by the students. The justification of their choices is the important point here.

   a. silicon putty

      Silicon putty is a fluid because it flows very slowly if left on a flat surface.

   b. a rubber ball

      A rubber ball is a non-fluid because it retains its shape and does not flow.

   c. butter on a hot day

      Butter is a fluid if it is hot enough for the butter to melt to a liquid. If it remains a solid, then it is a non-fluid.

d. gelatin (jelly) in the refrigerator

Gelatin may flow slightly over a period of time, so it is a very highly viscous fluid. If no change in shape takes place over a short period of time, it would be considered a non-fluid.

Section 1 Assignment

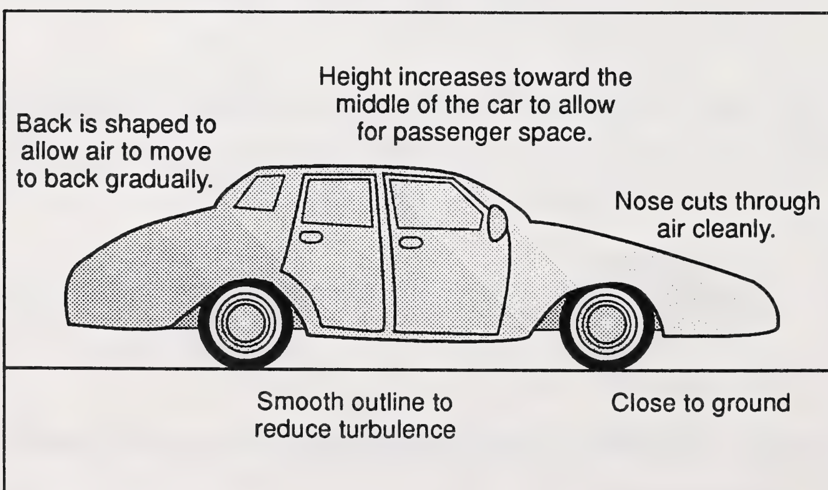
Marking Guide: Suggested values are given in brackets.

1. List as many fluids as you can find around your home. Do not ignore gases – they are fluids. (5 marks)

   Any liquids and gases found around the home and outside are correct. (The student should be encouraged to find more than the most obvious fluids such as air, water, and milk, etc.) Many household products are suitable. Examples are water, natural gas, air, bleach, maple syrup, window cleaner, dishwashing detergent, shampoo, milk, and apple juice.

2. Design an automobile that would be able to move through air with the least amount of resistance. It must have four wheels and room for six people. Either draw it and label its special design features or write out a detailed description of your design with sketches. Explain why your car is shaped the way it is. (5 marks)

   The answers will vary. The design should show some streamlining to allow it to move through the air with as little resistance as possible. Diagrams should be clear and labelled.



3. Each winter in Alberta, cracks occur in the pavement of roads due to frost heaves. These cracks are repaired with tar. In the repair, hot tar is poured over the cracks. Why do you think the tar is applied while it is hot? (3 marks)

   The tar is applied while it is hot so that it has a low viscosity. With low viscosity, the tar will pour well and flow into the cracks so that they are filled. The excess tar will form a thin layer on the pavement, rather than forming a bump.

Section 2: Buoyancy

In this section the students will learn about buoyant forces. These are the forces that fluids exert on other fluids and solids that are contained in them. The relationship between buoyant forces and floating is introduced. Practical applications of buoyant forces are presented.

Section 2: Activity 1

The following materials are needed for this activity:

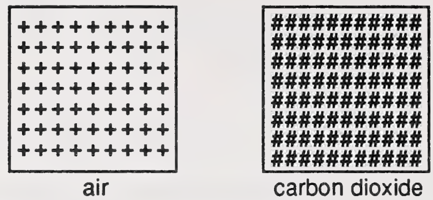
- a 600 mL beaker or other similar sized measuring container
- a 250 mL beaker
- a 100 mL graduated cylinder
- a 5 mL measuring spoon or a teaspoon
- a short candle about 3 cm high
- vinegar
- baking soda
- a small piece of cardboard about 15 cm square
- a match

A can of pop can be used as a source of carbon dioxide instead of the baking soda, vinegar, and measuring spoon. A pair of pliers can be used to place the lit match inside the beaker in order to light the candle which is to be at the bottom of the beaker.

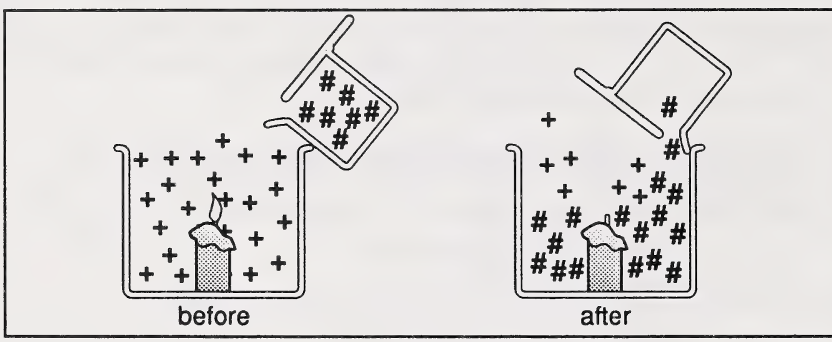
1. Describe what happened to the flame when the gas was poured on it.

   The flame should have gone out. If it didn't, students should repeat the experiment and make sure that the gas is poured down the side of the beaker.

2. When baking soda and vinegar are mixed, or when a soft drink is poured, carbon dioxide is produced. Draw a diagram that shows what you think happened to the air and carbon dioxide during this investigation. Use the designs indicated in the legend to show the air and the carbon dioxide in "before and after" diagrams.



The student should show a "before and after" diagram. The first diagram should show air around the candle flame; the second should show carbon dioxide at the bottom of the container with the flame out and air near the top of the container.



3. Use the words *float* and *displace* to describe what happened to the air and the carbon dioxide.

The answer should be a brief description of the diagrams for question 2. A sample response follows: The carbon dioxide ***displaces*** *the air at the bottom of the container, smothering the flame, and the air tends to* ***float*** *up on the carbon dioxide.*

Section 2: Activity 2

The following materials are needed for this activity:

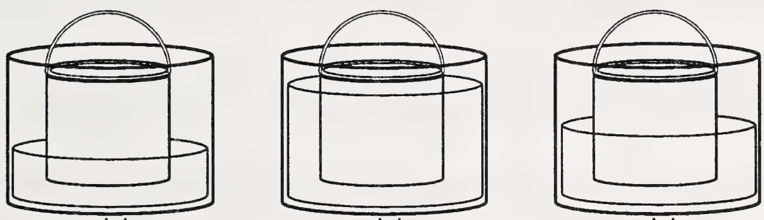
- a pail
- an ice-cream bucket or similar container having a capacity of about 4 L
- water
- glycerol
- vegetable oil
- about 4 L of sand, soil, or gravel
- a 600 mL beaker or other suitable measuring container
- a 500 g mass or a stone of about the same mass
- a spring scale graduated to tenths of newtons that can measure up to at least 5 N

If a stone is used in place of a 500 g mass, string can be used to attach the stone to the scale. A fishing weight may also be used. Another alternative is to use approximately 500 g (5 N) of sand or gravel in a freezer bag as a substitute for the 500 g mass.

1. What happened to the weight of the sand-filled bucket as you lowered it into the water?

   The apparent weight of the sand-filled bucket decreased as it was lowered into the water.

2. Describe the weight of the sand-filled bucket in the three positions illustrated. Indicate in which position the bucket weighs the most, the least, and in between.



weighs	weighs	weighs
the most	*the least*	*in between*

   Students should fill in the blanks, indicating in which position the sand-filled bucket will weigh the most, the least, and in between.

3. Make a rule about buoyant forces by filling in the blanks with the following words:

   displaces buoyant volume

   The greater the *volume* of fluid that an object *displaces*, the greater the *buoyant* force will be.

4. What do you think caused the sand-filled bucket to weigh less when it was in the water? Use the words *buoyant force*, *displaced*, and *exerted* in your answer.

   Students should use the words in a way that suggests the meaning of the words. A sample student response follows: The sand-filled bucket ***displaced*** *some water. The water* ***exerted*** *an upward* ***buoyant force*** *on the sand-filled bucket.*

5. The weight of the 500 g mass in air is *5.0* N.

6. Complete the table.

Liquid	Weight in Liquid (N)
water	*4.2*
vegetable oil	*4.3*
glycerol	*4.0*

The values may vary; however, the mass should weigh the most in vegetable oil and the least in glycerol.

7. What happened to the weight of the 500 g mass when it was submerged into the three liquids?

In all three cases the weight decreased, but by different amounts for each liquid.

8. Calculate the buoyant force for each of the three liquids.

weight in air – weight in liquid = buoyant force

Answers will vary. As an example, using the figures given for questions 5 and 6, the buoyant force of water is 5.0 N – 4.2 N = 0.8 N.

9. Complete the table.

Liquid	Buoyant Force (N)
water	*0.8*
glycerol	*1.0*
vegetable oil	*0.7*

The ordering of the liquids and the magnitude of the forces may vary; however, the buoyancy should be the greatest in glycerol and the least in vegetable oil.

Section 2: Activity 3

The following materials are needed for this activity:

- four test tubes
- a test tube rack or support
- glycerol
- vegetable oil
- food colouring
- water

A test tube rack is not required for this activity. Test tubes may be placed in tall glasses for support. Make sure the glasses provide enough support by first placing water-filled test tubes in them. If the glasses provide stable support for full test tubes, the glasses will safely support test tubes partially filled with other liquids.

1. Which liquid do you think will sink to the bottom when all three liquids are mixed in a test tube? Use the buoyant forces exerted by the three liquids in the previous activity as a guide.

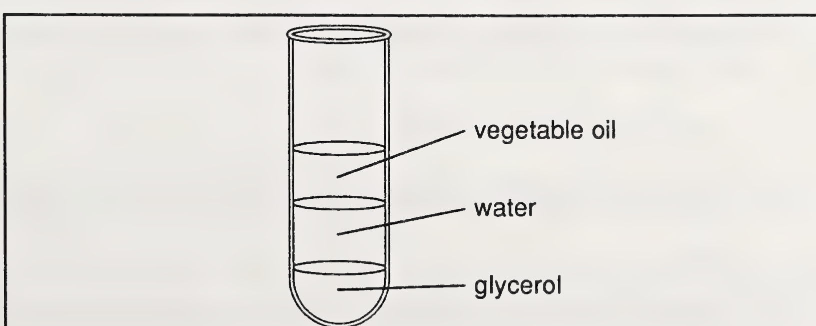
   a. The top liquid is *vegetable oil*.

   b. The middle liquid is *water*.

   c. The bottom liquid is *glycerol*.

   It is important that the students make some prediction; it is not important that the prediction is accurate.

2. Draw and label the layers of liquids as they appear in the test tube.



3. Fill in the table with the names of the liquids used.

The students are to fill in the table using the data they have collected in the previous activity. The two columns should have the same order of liquids, as shown below.

Liquid According to Position in the Test Tube		Liquid According to Buoyant Force	
Top	*vegetable oil*	*vegetable oil*	Least
Middle	*water*	*water*	Middle
Bottom	*glycerol*	*glycerol*	Greatest

4. Which liquid exerted the greatest buoyant force in this investigation? Explain your answer.

Students are to explain what evidence there is to suggest that one liquid exerts a greater buoyant force than the others. A sample response: The glycerol exerted the greatest buoyant force because it was able to displace both the water and the vegetable oil in the test tube. Of the three liquids, it also made the 500 g mass lose the most weight because it applied the greatest buoyant force on the weight.

5. You have completed three activities that dealt with the buoyant forces of fluids. In your own words, what does *buoyancy* mean?

Buoyancy is an upward force on an object in a fluid caused by the displacement of the fluid by the object. The size of the force is related to the amount of the fluid displaced.

6. Based on the investigations in this section, indicate whether the following statements are true or false by writing **T** or **F** behind each statement.

   a. One gas can displace another gas. ___*T*___

   b. The buoyancy of a liquid on a solid depends on the volume of the liquid displaced by the solid. ___*T*___

   c. The buoyant force on an object depends on the type of liquid used. ___*T*___

   d. One liquid can displace another liquid. ___*T*___

Section 2: Follow-up Activities

Extra Help

Fill in the following description of this section's activities using the words from the word list. Each word is used once.

liquids	weight	gas
appear	upward	smallest
top	loss	bottom
force	newtons	buoyant
displace		

In the first activity you learned that one *gas* can push aside, or *displace*, another. The carbon dioxide exerted a *buoyant* force on the air and pushed it up and out of the way.

In the second activity you showed that objects put into water *appear* to lose *weight*. The apparent *loss* in weight is called the buoyant *force* exerted on that object. Buoyant force is measured in *newtons* and is always an *upward* force.

In the third activity you learned that liquids can exert a buoyant force on other *liquids*. The liquid that exerted the greatest buoyant force is at the *bottom* of the test tube. The liquid that exerted the *smallest* buoyant force is at the *top* of the test tube.

Enrichment

1. You have learned that fluids exert a buoyant force on objects in them. How could you measure the buoyant force of the air on an object?

   A possible student response would be as follows: Measure the weight of an object in air and then place it in a vacuum, where there is no air. Weigh it in the vacuum. The difference between the two measurements will be the buoyant force of the air on the object. This force would be found to be very small.

2. You weigh less in water than in air because water applies a greater buoyant force than air. If you were able to weigh yourself in helium, would you weigh more or less than in air? Explain your answer.

   You would weigh more in helium than in air. This is because the buoyant force of a gas as light as helium is very low, even compared to a gas like air. Since the buoyant force of air is greater than that of helium, you would weigh less in air than in helium.

Section 2 Assignment

Marking Guide: Suggested values are given in brackets.

1. One day while you are swimming, you notice that you start to sink slowly when you stop swimming. Describe the sizes and directions of forces acting on you. Use the terms that you have been using in this section. (3 marks)

   There is the force of gravity acting on you in a downward direction. It is equal to your weight when you are not in the water. Acting in an upward direction is the buoyant force of the water. The force of gravity is slightly greater than the buoyant force of water, resulting in your sinking slowly.

2. When you put on a life-jacket, you float easily. Describe the forces acting on you. Compare these forces to those that you described in question 1. (3 marks)

   The force of gravity and the force of buoyancy are still acting on you, except now the buoyant force of the water on you and your life-jacket is greater than the downward force of gravity.

3. Why do you think the forces are different in the two situations described in questions 1 and 2? (4 marks)

   The buoyant force in the second situation is greater because there is a greater volume (you and the life-jacket). The buoyant force increases as the volume increases. The force of gravity increases only a small amount with the life-jacket since it is light..

4. The weight of a certain object in air was measured to be 9.8 N. When this object was immersed in glycerol, its apparent weight was found to be 6.1 N. What was the buoyant force on the object while it was in the liquid? Show how you obtain your answer. (2 marks)

   The buoyant force was 9.8 N – 6.1 N = 3.7 N.

Section 3: Density of Fluids

In the previous section students were introduced to some of the concepts that help determine if things will float or sink in fluids. This section will continue along this line by introducing the idea of density and making a hydrometer to measure it with.

In this section students will learn why things float and sink, the meaning of density and its relationship to buoyancy, how to make an instrument that can measure density, and the relationship between the temperature and the buoyancy of a fluid.

Section 3: Activity 1

Students may do either Part A or Part B.

The following materials are needed for Part A of this activity:

- a balance
- a 100 mL graduated cylinder
- a beaker or other container
- a dropper
- glycerol
- vegetable oil
- water

No materials or equipment are needed for Part B of this activity. Students should do Part B if a balance is not available.

1. What is the problem?

   The problem may be stated as follows: What determines whether something floats on a fluid?

2. Fill in the first two columns of the table.

   An example of the data that students may obtain is shown below.

Mass of Different Liquids – Same Volume				
Liquid	**Mass of Graduated Cylinder (g)**	**Mass of Graduated Cylinder + Liquid (g)**	**Mass of 50 mL of Liquid (g)**	**Mass of 1 mL of Liquid (g)**
glycerol	*78*	*141*		
vegetable oil	*78*	*123*		
water	*78*	*128*		

3. Do steps 1. (a) and 1. (b) in Analysis on your own paper and fill in the last two columns of the table that appears in question 2.

The following is a sample answer based on the data presented in question 2.

Mass of Different Liquids – Same Volume				
Liquid	Mass of Graduated Cylinder (g)	Mass of Graduated Cylinder + Liquid (g)	Mass of 50 mL of Liquid (g)	Mass of 1 mL of Liquid (g)
glycerol	78	141	*63*	*1.26*
vegetable oil	78	123	*45*	*0.9*
water	78	128	*50*	*1.0*

4. What is the problem?

The problem may be stated as follows: What determines whether something floats on a fluid?

5. Do steps 1. (a) and 1. (b) from Analysis on your own paper and fill in the last two columns of the table on the preceding page.

Students should complete the table as follows

Mass of Different Liquids – Same Volume				
Liquid	Mass of Graduated Cylinder (g)	Mass of Graduated Cylinder + Liquid (g)	Mass of 50 mL of Liquid (g)	Mass of 1 mL of Liquid (g)
glycerol	78	141	*63*	*1.26*
vegetable oil	78	123	*45*	*0.9*
water	78	128	*50*	*1.0*

6. In the first column of the table that follows question 8, list the liquids according to their buoyant forces on the solid. List them in order from least to greatest force.

   See the chart that follows question 8 for answers.

7. In the middle column of the table that follows question 8, label the liquids in the container in the order that you found them in the activity. Write the names of the liquids right on their positions in the container.

   See the chart that follows question 8 for answers.

8. Complete the third column of the table using the data from this investigation. List the liquids in order from least to greatest mass per millilitre (density).

Comparing Buoyant Force and Mass				
	Buoyant Force on Solid	**Buoyant Force on Liquid**	**Mass of 1 mL of Liquid (g)**	
least	*vegetable oil*	*vegetable oil*	*vegetable oil*	least
	water	*water*	*water*	
most	*glycerol*	*glycerol*	*glycerol*	most

9. By comparing the buoyant forces and the masses of a certain volume of the three liquids in the preceding chart, can you suggest a way that you can predict whether something will sink or float in a fluid?

   An object will float in a given liquid if the mass of one millilitre of the object is less than the mass of one millilitre of the fluid. For example, the vegetable oil floats on water because it has a mass of 0.9 g/mL, which is less than the mass of water.

Section 3: Activity 2

1. What are the two measurements you have to make to determine the density of a substance?

   Both volume and mass have to be measured in order to determine density.

2. By using the example of feathers and gold on the page that you just read, state what density means.

   The wording may vary but students should answer as follows: The density of gold is greater than the density of feathers because gold has a large mass for its size or volume, as compared to feathers. Feathers take up a large volume for their mass, as compared to gold.

3. Which of the fluids listed in Table 2-5 will exert the greatest buoyant force on a solid that is submerged in it?

   Mercury will exert the greatest buoyant force.

4. Which of the fluids listed in Table 2-5 will exert the least buoyant force on a solid that is submerged in it?

   Helium will exert the least buoyant force.

5. Answer questions 2. (a) and 2. (b) in Activity 2-10 on page 81 of your textbook.

   Textbook question 2. (a):

   Nitrogen and helium are less dense than air.

   Textbook question 2. (b):

   Oxygen and carbon dioxide are more dense than air.

6. Answer questions 3. (a) and 3. (b) in Activity 2-10 on page 81 of your textbook.

   Textbook question 3. (a):

   Lead, copper, nickel, iron, aluminum, and salt will float on mercury.

   Textbook question 3. (b):

   Gold will sink in mercury.

7. Explain in your own words why ships made of steel can float.

   Steel ships float because of the large amount of low-density air inside them. As a result, the average density of the ship, the cargo, and the air is less than the density of the water.

Section 3: Activity 3

The following materials are needed for this activity:

- three beakers or glasses
- vegetable oil
- glycerol
- water
- sugar
- a teaspoon or a 5 mL spoon

The student may also require a selection of the following, depending on the design of the student-made hydrometer:

- sand
- a wooden dowel about 6 cm to 8 cm long
- a short wood screw
- a candle
- several thumbtacks
- a drinking straw
- modelling clay

1. What is the problem?

   The problem can be stated as follows: Can you make an effective hydrometer and use it to measure the density of a liquid?

Comment:

For question 2 the textbook questions come from page 83.

2. Do step 2 from Part A of Activity 2-11 and answer the questions that follow.

   Textbook question 2. (a):

   The hydrometers should float in all of these liquids.

   Textbook question 2. (b):

   The student should be able to put a scale on hydrometers A and D. Hydrometers B and C may present some difficulties.

Textbook question 2. (c):

It would be unlikely for these hydrometers to separate the densities of similar liquids because of their crudeness.

Textbook question 2. (d):

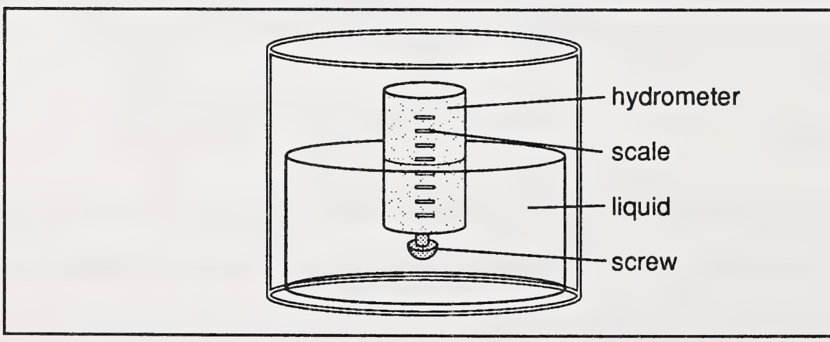
The wooden hydrometer may absorb liquid and its mass would change. The others should be reusable if they are kept clean.

Textbook question 2. (e):

To measure the density of denser materials with a hydrometer, more of the weighting materials (tacks, sand, screws) could be added to the hydrometer. For less dense materials, less of the weighting materials would be used.

3. Make an accurate labelled sketch of your best hydrometer. Explain why you chose it as your best.

   The following could be listed as reasons for choosing a certain hydrometer: it was easy to make, it gave repeatedly accurate readings, it allowed for the making of a useable scale. Drawings will vary, depending on the type of hydrometer made. The actual hydrometer should be drawn.



4. Predict whether the hydrometer will float higher or lower in the sugar solution than it would in pure water.

   A correct prediction would be that the solution will get denser and the hydrometer will float higher. Incorrect predictions should not be marked wrong.

5. Record your observations.

   The observations should show the hydrometer floating higher in the sugar solution than in the pure water.

6. You can make the following inference based on your observation: The *density* of the sugar solution increases as the *concentration* of the solution increases.

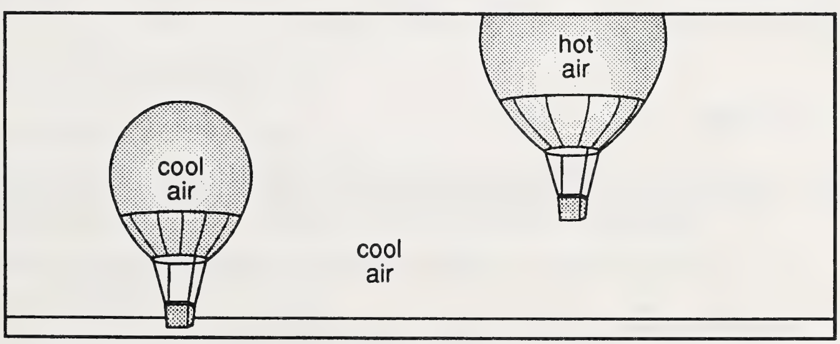
Section 3: Activity 4

1. What is the usual effect that heating has on the volume and density of an object?

   Heating, in almost all situations, causes the substance to increase in volume and to decrease in density.

2. Explain in your own words how a hot-air balloon floats in the air. Use diagrams to help explain your answer.

   The air inside the balloon is heated to a temperature higher than the surrounding air. The air expands, giving it a lower density than the surrounding cooler air. When the average density of the entire balloon is less than the surrounding cooler air, it starts to rise or float in the more dense air.



Section 3: Follow-up Activities

Extra Help

Fill in the blanks with the expression provided. Each expression is to be used just once.

gold	density	measure
liquid	lower	higher
volume	liquid metal	low
hydrometer	buoyant	19.32 g/mL
19 mL	mass	high
less	13.55 g/mL	

Density is the comparison of an object's *mass* with its *volume*. For example, feathers have a *low* density and lead has a high *density*. Things float in water if they have a density of *less* than 1 g/mL. Mercury is a very dense *liquid metal*. It exerts a very strong *buoyant* force on an object. One of the few materials that will sink in mercury is *gold*. This is because the density of gold is *19.32 g/mL*, compared to *13.55 g/mL* for mercury. A *hydrometer* is an instrument that is used to *measure* the density of a *liquid*. It floats *higher* in dense liquids and *lower* in less dense liquids. Ice floats on water because its density is less than *1 g/mL*.

Enrichment

1. Answer question 5 in Activity 2-10 on page 81 of your textbook. Use the table on page 80 to help you determine the type of metal that the block is made of.

   To determine the density of an object you need to know the mass and the volume of the object.

   $$\begin{aligned} \text{length} &= 5\text{ cm} \\ \text{width} &= 3\text{ cm} \\ \text{height} &= 2\text{ cm} \\ \text{mass} &= 235\text{ g} \\ \text{volume} &= l \times w \times h \\ &= 5\text{cm} \times 3\text{cm} \times 2\text{cm} \\ &= 30\text{cm}^3 \end{aligned}$$

   $$\begin{aligned} \text{density} &= \frac{\text{mass}}{\text{volume}} \\ &= \frac{235\text{ g}}{30\text{ cm}^3} \\ &= 7.83\text{ g/cm}^3 \end{aligned}$$

   The table of densities on page 80 shows that the metal is probably iron.

2. A metal ship floats because the average density of the steel, the cargo, and the air in the ship is less than the density of the water it is floating in.

   a. Why does a ship sink if it starts to leak?

      A steel ship sinks because its density increases as it takes on water. There comes a point when the ship is so full of water that the average density of the ship, the cargo, the leaking water, and the remaining air is greater than 1.0 g/cm^3. At that point the ship sinks below the less dense water.

   b. How would you raise a ship that has sunk?

      You could raise the ship by repairing the hole in the ship and then pumping air into the hull. Another possibility is to pump a low-density solid, like plastic, into the hull to lower the ship's density and cause it to float.

Section 3 Assignment

Marking Guide: Suggested values are given in brackets.

1. Answer questions 1. (a) and (b) on page 86 of *Science Directions 9*. (Total of 11 marks)

   Textbook question 1. (a): (2 marks for each definition)

   force: A force is a push or pull applied to an object or substance.

   buoyant force: A buoyant force is the upward force of a fluid on another object or substance.

   displace: Displace means to push aside.

   Textbook question 1. (b): (5 marks)

   The buoyant force of the water on the rock makes the rock appear to weigh less and makes it easier to carry. If it is held above the water, the rock's full weight has to be supported.

2. Answer questions 3. (a), (b), and (c) on page 86 of your textbook. (Total of 4 marks)

   Textbook question 3. (a): (1 mark)

   The red western cedar and the birch will float on water because their densities are less than 1.0 g/mL.

   Textbook question 3. (b): (2 marks)

   There are no solids listed that will float on air because none listed have a density of less than 0.0013 g/mL.

Textbook question 3. (c): (1 mark)

The solids that will float on mercury are red western cedar, birch, sugar, salt, aluminum, iron, nickel, copper, and lead. This is because their densities are less than 13.55 g/mL.

Section 4: Fluid Pressure

In this section students will learn what happens when forces are applied to fluids. Some of the properties of pressure in liquids will be studied. Students will also learn how people live with water pressure and air pressure and investigate instruments that measure air pressure.

Section 4: Activity 1

The following materials are needed for this activity:

- a 50 mL modified syringe
- a solid rubber stopper with a hole bored halfway through it. The diameter of the hole should be slightly smaller than that of the tip of the syringe so that the syringe tip fits snugly.
- four masses (each weighing about 1 kilogram)
- a 250 mL beaker or container

A support stand and two burette clamps would be best, but the modified syringe can be held in place by another person. As before, hard-cover books can be used as a load for the syringe. Each book should have a weight of about 10 N (a mass of about 1 kg). A spring scale can be used to select the books.

1. What does *pressure* mean?

   Pressure is the amount of force applied over a certain area.

2. What is the problem?

   The problem may be stated as follows: How do fluids respond to a force?

3. Complete the table.

An example of the results is given below. The figures in the second column may be somewhat different if books are used. The figures in the third column will vary, but should decrease with more force. The figures should show that as force increases, additional force has less effect. The figures in the final column should be constant.

Compressibility of Air and Water			
Mass on Piston (kg or books)	**Force on Confined Fluid (N)**	**Volume of Air (mL)**	**Volume of Water (mL)**
0	0	50	50
1	*10*	*41*	*50*
2	*20*	*35*	*50*
3	*30*	*32*	*50*
4	*40*	*30*	*50*
0	*0*	*49*	*50*

Comment:

For questions 4 and 5, the textbook questions come from pages 88 and 89.

4. Answer questions 1. (a) and 1. (b) from Analysis on page 89.

   Textbook question 1. (a):

   The force causes the gas to take up less volume.

   Textbook question 1. (b):

   The force has no visible effect on the liquid.

5. Answer questions 3. (a) and 3. (b) from Analysis.

   Textbook question 3. (a):

   The gas rebounded to almost its previous volume.

Textbook question 3. (b):

The liquid stayed at the same volume as before (50 mL).

6. Use the particle theory to explain your observations.

   The answer should include an understanding that gases have larger spaces between the particles than liquids. This allows the particles in a gas to be pushed closer together and reduce the volume of the gas. The volume cannot be reduced with liquids because there is little space between the particles.

   Example: It is easier to compress a gas because there is a lot of space between the particles.

7. Fill in the blanks with the correct word.

   Gases are ___*compressible*___ (incompressible, compressible) fluids and liquids are ___*incompressible*___ (incompressible, compressible) fluids.

8. Where around your house is it important to use a compressible gas? Why must it be compressible?

   A good answer would include any place where air is put in a container and used to absorb shock, such as in a car or bicycle tire. Compressed gases supply the force required to spray out the contents of aerosol cans.

Section 4: Activity 2

1. Explain what happens to the pressure in each of the following situations.

   a. You take off your boots and put on your skates.

      The pressure increases when the skates are put on because the area of the skate blade is much less than the area of the boot soles. So with the decreased area and the same force, the pressure increases.

   b. You put on a 300 N backpack while you are out on a cross-country skiing trip.

      The pressure on the snow increases because the area of the ski bottoms stays the same, but the force on the skis increases, so the pressure increases.

2. The basic unit of pressure is the *pascal*. It is equal to

   1 *N* / *m^2*.

3. The more common pressure unit is the *kilopascal*.

4. What is the pressure at the bottom of a cubic metre of water? Give an answer for both Pa and kPa. *10 kPa* or *10 000 Pa*.

5. In what directions do fluid pressures act?

   Fluid pressures act in all directions. The textbook photographs on page 94 help to illustrate this fact.

Section 4: Activity 3

1. The normal air pressure at sea level is 101.3 kPa. What does this mean in terms of gravity, force, and pressure?

   The standard air pressure at sea level, 101.3 kPa, means that there is a weight of 101 300 N of air over the average square metre of land at sea level. That is how much a 700 km column of air that is 1 metre square weighs. The earth's gravity is pulling down 700 km of air. This gravity exerts a force of 101 300 N on the air. The air pressure is 101.3 kPa.

2. Why does the air pressure decrease as you go up a mountain?

   The air pressure decreases as you go up a mountain because there is less and less air above you. Therefore, there is less weight of air on you, meaning that there is less pressure.

Comment:

Another important point (related to compressiblity of gases) is that since there is less pressure up in the atmosphere, the air that is at the top of a mountain is less compressed than the air at sea level. As a result, the air at the top of a mountain exerts less pressure, but it is also thinner.

3. If you blow up a balloon at sea level and then travel in an car up a high mountain, what will happen to the balloon? Explain your answer.

   The balloon will expand as it goes up the mountain. This is because the air inside the balloon is trapped at the pressure you blew it up at. However, the pressure outside the balloon on the way up the mountain decreases. The greater pressure inside the balloon will cause it to expand.

4. Why is the pressure under 10 m of water so much greater than the air pressure at sea level?

   The pressure under 10 m of water is so much greater because of the much greater density of the water, as compared to air. It only takes a few metres of water to apply the same pressure as 700 km of air.

5. If you inflate a balloon and take it down to 50 m under water, what will happen to it? Why?

   The balloon will shrink to a small size because of the steadily increasing pressure as it descends into the water. The air inside the balloon will be compressed.

Section 4: Activity 4

What is actually needed for this activity will depend on the design of the student-made barometer; however, the following materials are likely needed:

- one empty coffee can or other large can
- a drinking straw
- a balloon
- tape
- cardboard or wooden board
- elastic band
- paper
- glue

Students will be seeking approval from you for their barometer design. Be sure the design is safe and requires only materials that are available.

1. Name the two different types of barometers and briefly describe them.

   The mercury barometer depends on air pressure to force mercury up a glass tube. The weight of the mercury in the column equals the pressure of the air at that time. The mercury rises and falls as the air pressure changes. An aneroid barometer has a sealed chamber of air with a flexible covering. When the outside pressure increases or decreases, the air pushes in or out on the covering, changing the dial reading.

2. What is the problem?

   The problem may be stated as follows: Can you make a workable barometer?

Comment:

For question 3, the textbook questions come from page 99.

3. Do question 1 of Analysis on page 99 of your textbook.

   The answer to the first part of this question will depend on the air pressure during the investigation. It should vary between 102.0 kPa and 99.0 kPa.

   The second part of the answer will depend on the amount of movement shown by the straw over a few days. Movement over a couple of centimetres should make the different pressures show clearly.

4. Why does your barometer change with the change in air pressure?

   The air in the barometer is sealed off from the outside. As a result, when the outside air pressure decreases, the inside pressure pushes outward on the balloon covering of the can. This causes the straw to move on the scale.

5. Why should your barometer be kept at the same temperature for accurate readings?

   The barometer contains air and if the temperature was allowed to rise, the air could expand, lifting the pointer and giving a false pressure reading.

6. What improvements could you make to your barometer?

   The answers will vary, depending on the barometer constructed. Example: You could use a longer straw, keep the barometer at a more constant temperature, and remove the air from inside the can.

Section 4: Follow-up Activities

Extra Help

Fill in the blanks below with words and expressions from the list. Use each expression or word once.

garden hoses	force	decrease	area
increase	your heart	aerosol cans	tires
do not	incompressible	submarines	pressure
all directions	less air	water pistols	gases
barometer	N/m^2	pascal	compressible

Pressure is the amount of *force* applied over a certain *area*. To make a garden hose shoot the water further, you can either *increase* the force or *decrease* the area of the opening. When pressure is applied to *gases*, they decrease in volume. That means that gases are *compressible*. Liquids *do not* change in volume when pressure is applied to them. They are *incompressible*. Compressible fluids are used in *tires*, *aerosol cans*, and *submarines*. Incompressible fluids are used in *water pistols*, *garden hoses*, and *your heart*. The metric unit for pressure is the *pascal*. It is defined as 1 *N/m^2*. The direction of the force of *pressure* in a fluid is in *all directions*. The air pressure decreases as you go up in the atmosphere because there is *less air* above you to apply pressure. An instrument that measures air pressure is called a *barometer*.

Enrichment

1. Do question 1 in Activity 2-14 on page 93 of your textbook. Use the following table that is provided. (The space beneath the table may be used to do your calculations.)

Calculation of Pressure	Block A	Block B
Volume of water	$1\ m^3$	$1\ m^3$
Mass of water	*1000 kg*	*1000 kg*
Force of gravity (F)	*10 000 N*	*10 000 N*
Bottom surface area	$10\ m^2$	$0.1\ m^2$
Pressure in N/m^2	$1000\ N/m^2$	$100\ 000\ N/m^2$
Pressure in kPa	*1 kPa*	*100 kPa*

Comment:

To calculate the values for the table, students should use the formulas given in Table 2-7 on page 93 of the textbook as a guide. The calculations for Block A are shown on the following page.

Volume of water $= l \times w \times h = .5\ m \times .2\ m \times 10\ m = 1\ m^3$

To calculate the mass of water, students need to determine the mass in $1\ m^3$ *of water, knowing that* $1\ cm^3$ *of water = 1 g.*

$$1\ m^3 = 100\ cm \times 100\ cm \times 100\ cm = 1\,000\,000\ cm^3 = 1\,000\,000\ g$$
$$= 1000\ kg$$

From Table 2-7 in the textbook, the force of gravity on 100 g = 1 N; thus the force of gravity on 1 000 000 g or 1000 kg is 10 000 N.

Bottom surface area $= l \times w = 5\ m \times 2\ m = 10\ m^2$

$$Pressure = \frac{Force}{Area} = \frac{10\,000\ N}{10\ m^2} = 1000\ N/m^2$$
$$= 1\ kPa$$

2. Regarding the direction of pressure, how is fluid pressure at the bottom of a swimming pool different from the pressure of a snowshoe on snow?

   The difference between the two pressures can be stated as follows: The pressure at the bottom of the swimming pool will be in all directions. The pressure on the snow will be in one direction only – down.

3. Why are airplanes pressurized when they fly at high altitudes?

   Airplanes are pressurized at high altitudes because the pressure is so low that human beings are unable to survive. Also, at high altitudes the air is so thin that there is not enough oxygen in the air to keep a person conscious.

Section 4 Assignment

Marking Guide: Suggested values are given in brackets.

1. In your own words, describe the role that compressed air has in the rising and submerging of a submarine. (Total of 8 marks. Individual marks are shown within the answer.)

   To submerge, the submarine fills its tanks, called ballast tanks, with water (2 marks). *This increases the density of the submarine, causing it to sink* (2 marks). *To surface, the submarine releases compressed air into the ballast tanks. This air pushes the water out of the tanks* (2 marks). *This decreases the density of the submarine to less than the density of water, and it rises to the surface* (2 marks).

2. One day the air pressure in your area is 103.0 kPa. Explain what you think could have caused this high pressure? (6 marks)

   The higher-than-normal air pressure means that there is more than the usual weight of air over that area. This could be caused by colder, denser air being over the area.

3. Why is the ride on your bicycle uncomfortably hard if you put too much air in the tires? Use what you know about the compressibility of air to explain your answer. (6 marks)

   A suitable response follows: In compressing the air in a syringe, I found that after there was some weight on the piston, additional weight had less effect. That means that air is compressible, but its compressibility decreases as pressure is increased. If you over-inflate the tire and hit a bump, the air cannot compress very much, so the bump is not absorbed by the air in the tire. If it's inflated properly, the air compresses and absorbs the bump before you feel it.

Section 5: Fluids at Work

Over the past four sections in this module, students have learned some of the properties of fluids. In this section they will discover some of the uses that society has for these substances. These include car hoists in garages, car brakes, the human heart, and water taps.

In this section students will learn how a hydraulic press works and the uses it can be put to. Students will also learn about the role of valves and pumps in hydraulic systems and the maintaining of fluid systems.

Comment:

Students are encouraged to look for examples of valves and pumps around them. If possible, disassembling and studying how they work is encouraged, but only under adult supervision.

Section 5: Activity 1

The following materials are needed for this activity:

- two 50 mL modified syringes
- one 10 mL modified syringe
- rubber or vinyl flexible tubing about 50 cm in length
- a 250 mL beaker or container
- a 1 kg mass

The syringes must have tips of the same outer diameter. The tubing must fit the syringe tips. As before, a partner can effectively hold the syringes in place so that clamps and support stands are not required. In place of the 1 kg mass, a book that weighs about 10 N may be used.

Students are to ask you what to do with the vegetable oil and glycerol that they have left after the investigations. These liquids may be saved for further use by other students. If there are no other students who will need these liquids, the liquids may be placed in jars with lids. The closed jars may be disposed of in the garbage.

1. What is the problem for this investigation?

   The problem can be stated as follows: Can a hydraulic press transfer force and change its strength?

2. Use the terms *less than standard force* and *more than standard force* to fill in the third column of the table at the top of the next page.

Size of Piston		Force Required
Effort (thumb)	**Load (1 kg mass)**	
same area	same area	standard force
smaller area	larger area	*less than standard force*
larger area	smaller area	*more than standard force*

Comment:

For question 3, the textbook question comes from page 105.

3. Do question 2 of Analysis on page 105 of your textbook.

   Applying the effort to the smaller syringe and setting the 1 kg load on the larger syringe was the arrangement that required the least force to raise the weight.

4. Make a rule about the effort required to lift a weight and the area of the piston through which the effort is applied. Use the results from the table as a guide.

   The investigation suggests the following relationship: The smaller the area of the effort syringe compared to the load syringe, the less effort is required to lift the load.

5. When you applied the effort to the small syringe, which syringe piston moved a greater distance?

   The smaller piston moved further than the larger piston.

Section 5: Activity 2

1. Study the illustration on page 107 of your textbook. The drawing is not to exact scale. Based on what you know about hydraulic systems, what are some of the factors that you could change in order to reduce the force required by the driver to apply the brakes? Give your reasons.

   Some of the factors that will reduce the force required to apply the brakes follow:

   - *The longer brake pedal will allow more force to be applied to the brakes with less effort by the driver.*
   - *If the brakes are power assisted, it will reduce the effort required by the driver to apply the brakes.*
   - *Using a narrower cylinder to reduce the area of the effort cylinder or increasing the surface area of load cylinder next to the brake pad would reduce the force required by the driver to apply the brakes.*

2. If the piston in the master cylinder is smaller than the piston in the wheel cylinder, which piston will travel further in its cylinder when the brakes are applied?

   The smaller piston in the master cylinder will move a greater distance than the piston in the wheel cylinder.

3. Fill in the blanks with the phrases *less than, the same as,* and *greater than.*

   A system is set up with a small piston applying a force to a large piston. The large piston moves ___*less than*___ the small piston. The pressure on the large piston is ___*the same as*___ the pressure on the small piston. The force on the small piston is ___*less than*___ the force on the large piston.

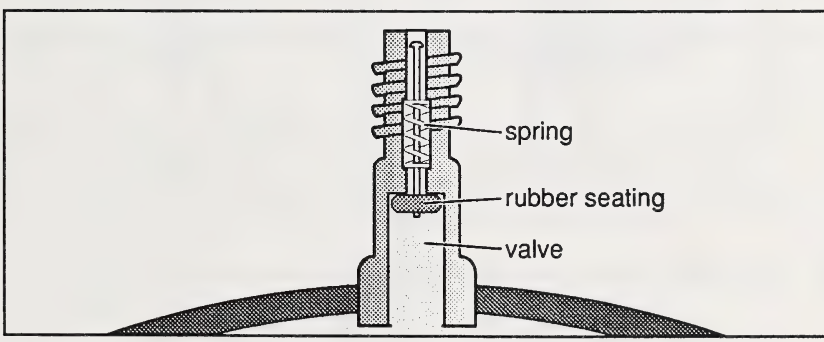
Another system is set up with a large piston applying a force to a small piston. The small piston moves *greater than* the large piston. The pressure on the small piston is *the same as* the pressure on the large piston. The force on the small piston is *less than* the force on the large piston.

Section 5: Activity 3

Materials required to build a simple valve will be needed for this activity. The actual materials needed will depend on the student design. The design should involve only easily obtainable materials, such as a drinking straw, a balloon, a cup, a marble, a piece of hose or tubing, and a paper clip.

1. a. Study a tire valve on your bicycle or on a car or truck. Draw a cross section (a wide view as if its cut through the middle) of the valve.

   Answers may vary, but diagrams should show a seating and a valve (stem) oriented as shown.



   b. What is the purpose of the tire valve?

   The purpose of the tire valve is to prevent air from leaking out of the tire. The valve stem also makes it possible to put air into the tire easily.

   c. Describe how you think the valve works.

   The spring in the valve keeps the rubber seal firmly against a metal ring, keeping the air from escaping from the tire. When it's required to add air to the tire, the central stem to which the rubber ring is attached is depressed by the nozzle of the air hose. This allows air to rush into the tire if it's being filled, or air to rush out if you are deflating your tire.

2. What is the purpose of the valves in your heart?

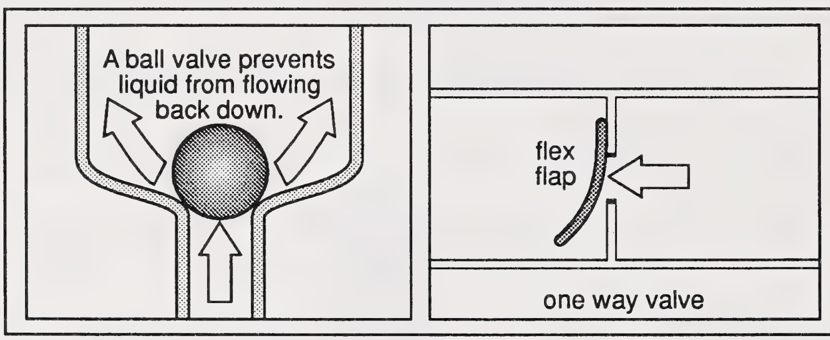
   The valves in your heart prevent the blood from going backwards between pumps of the heart. They make sure that the blood only goes in one direction.

3. What is the problem?

   Making a simple valve from household materials is the problem.

4. Make a preliminary sketch of your valve.

   Answers will vary. Two sample diagrams are shown.

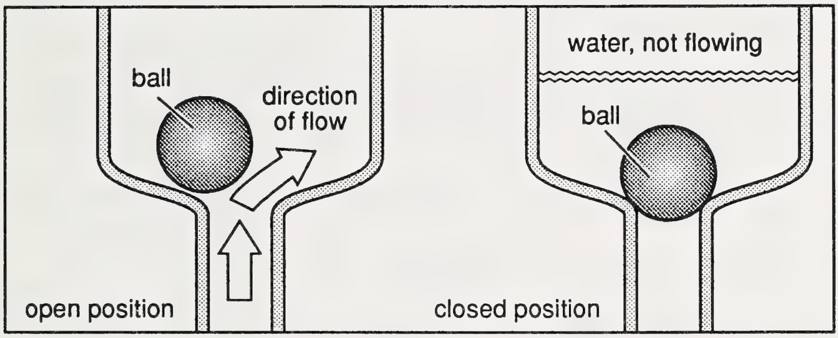


5. What changes would you make to the valve to make it a better product? Why?

   The changes will vary. They should include things that will make the valve more reliable, sturdy, or easy to make.

6. a. Draw and label your improved valve in the open and closed positions. Include the direction of the flow of fluid through the valve.

The diagrams can vary. A sample is shown.



b. What could the valve be used for?

The answers will vary. They should be reasonable regarding reliability, strength, and simplicity for the job intended.

7. What is the advantage of making a model of your valve early in the exercise?

It is easier to detect any major problems with the basic design if you build a model right away.

Section 5: Activity 4

Comment:

For question 1, the textbook questions come from page 111.

1. Do questions 1. (a), (d), (e), and (f) on page 111.

Textbook question 1. (a):

There are two valves in the pump.

Textbook question 1. (d):

The water remains stationary in stage (c) while the piston goes down.

Textbook question 1. (e):

In stage (d) the handle is being pushed down. This means that water is rising inside the pump, pushing open the bottom valve. The top valve is closed because it is rising in the water. This forces it closed.

Textbook question 1. (f):

It may take several pumps of the handle to fill the inside reservoir of the pump with water. It is only then that the water can come out of the spout.

2. List three examples where you are the source of power in a hydraulic system.

   The following are some possible answers:

   - *a bicycle pump*
   - *blowing up a balloon*
   - *a water pistol*

3. a. Aerosol spray cans do not have a pump in them. What causes the contents to spray out of the cans when the valve is depressed?

      The spray comes out due to the high-pressure gas that has been put into the can at the factory. The gases and liquids rush out of the can when the valve is depressed.

   b. What feature must these spray cans have to make them safe to use? Why?

      They must be strong to be able to contain the high pressure. If they weren't strong enough, there would be a danger of their exploding due to the high pressure inside.

Section 5: Activity 5

1. Why is it important that the pressure in a fluid system be controlled and known?

   It is important that the pressure in a fluid system be controlled and known because the pressure causes stress on the walls of the fluid's container and causes leakage and accidents. Also, the build up of dirt or other debris can cause an increase in pressure at certain times, so knowing the pressure in a system can be used to determine the condition of the system.

2. Why do you think that it is unhealthy to have high blood pressure?

   With high blood pressure there is a risk that the blood vessels won't be strong enough to handle the pressure, and they may burst. This situation can be life-threatening if it occurs in a vital organ like the brain.

3. a. What are some of the problems that can occur in a fluid system?

One of the main problems in a fluid system is friction. Friction is always present, but it can be made worse by corrosion and dirt buildup. Another problem is leakage. Leakage can decrease the efficiency of the transfer of forces in the system or can lead to a loss of the material being transported.

b. How are these problems solved?

These problems are solved by constant cleaning of the inside of fluid systems. This reduces friction. The systems are also constantly attended for any leakage, both inside and outside.

Section 5: Follow-up Activities

Extra Help

Match up the columns below by placing the letters from the second column in the appropriate space provided in the first column.

b	1. friction	a. something that controls the flow of liquid
d	2. heart	b. this makes fluid systems lose their pressure
h	3. pressure	c. a material often transported by pipeline
i	4. bicycle pump	d. an example of a pump containing four valves
f	5. hydraulic press	e. something that supplies the force to a system
g	6. pressure loss	f. where fluids are used to make work easier
c	7. natural gas	g. dirty pipes suffer from this
e	8. pumps	h. the force per unit of area in a system
a	9. valve	i. a pump where you supply the energy

Enrichment

1. Do questions 6. (a) to (e) on page 105 of your textbook.

   Some sample calculations have been filled in.

   Textbook question 6. (a):

   $r_{large} = \underline{\mathit{2.0}}\ \text{cm}$

   $r_{small} = \underline{\mathit{1.0}}\ \text{cm}$

   Textbook question 6. (b):

   $$\begin{aligned} A_{large} &= \pi r^2 \\ &= \underline{\mathit{12.6\ cm^2}} \end{aligned}$$

   $$\begin{aligned} A_{small} &= \pi r^2 \\ &= \underline{\mathit{3.1\ cm^2}} \end{aligned}$$

   Textbook question 6. (c):

   $F = 10\ \text{N}$

   $A_{large} = \underline{\mathit{12.6}}\ \text{cm}^2$

   $$\begin{aligned} P_{large} &= \frac{F}{A} \\ &= \frac{\mathit{10\ N}}{\mathit{12.6\ cm^2}} \end{aligned}$$

   $P_{large} = \underline{\mathit{0.8}}\ \text{N/cm}^2$

   $F = 10\ \text{N}$

   $A_{small} = \underline{\mathit{3.1}}\ \text{cm}^2$

   $$\begin{aligned} P_{small} &= \frac{F}{A} \\ &= \frac{\mathit{10\ N}}{\mathit{3.1\ cm^2}} \end{aligned}$$

   $P_{small} = \underline{\mathit{3.2}}\ \text{N/cm}^2$

Textbook question 6. (d):

The piston in the small syringe exerted the greater pressure.

Textbook question 6. (e):

The smaller the area of the piston, the greater the pressure it causes in the fluid system (assuming that the force is kept constant).

2. Answer questions 2. (b), (c), and (d) on page 111 of your textbook.

   Textbook question 2. (b):

   As the water is forced out of the spout of the pump, the air in the dome is compressed by the water pressure. As the pump handle is being lifted, the air pressure continues the flow of water out of the spout. There is a continuous stream of water.

   Textbook question 2. (c):

   The compressed air in the dome forces the water out of the spout even while the pump handle is being raised.

   Textbook question 2. (d):

   The narrow nozzle allows the pressure to build up inside the spout so the water may continue to flow when the pump handle is on an upward motion. With a wide spout, little or no air pressure could build up in the dome between pumps of the handle.

Section 5 Assignment

Marking Guide: Suggested values are given in brackets.

1. Do question 3 of Analysis in Activity 2-16 on page 105 of your textbook. Suggest three possible modifications. (Total of 6 marks. Individual marks are given within the answer.)

   In order to lift the 1 kg mass with less force, you could use a smaller syringe to apply the force to the mass (2 marks). *You could also put the 1 kg mass on a larger syringe* (2 marks). *You could also lubricate the pistons in the syringes or use an oil, rather than water, to reduce the force of friction* (2 marks).

2. Hydraulic presses can be used for transferring forces from one place to another. Gears, pulleys, and chains can also be used for this purpose. What are the advantages of using hydraulic presses, rather than gears, pulleys, and chains? Use examples to make your points. (7 marks)

   The advantages in hydraulic systems are that they allow the source of the force, the pump, and the place where the force is used to be separate and able to move independently. For example, the blade of a bulldozer is free to move separately from the source of the force, the engine. It would be difficult with gears and pulleys. Hydraulic systems can work very smoothly, as in a front-end loader. Also with a hydraulic system, there are fewer moving parts than with a mechanical system. For example, in a braking system of a car, the braking fluid replaces a cable.

3. a. If you did Activity 2-16 of your textbook with molasses instead of water, what differences would you have noticed in the flow of the fluid? Explain. (4 marks)

   The force required to lift the 1 kg mass would have been greater than in the same situation using water because of the greater viscosity of the molasses.

   b. Without heating it, how could you make the molasses flow more quickly between two syringes connected as a hydraulic system? (3 marks)

   You could connect the syringes with wider tubing (of larger inside diameter) and widen the tips of the syringes .

Final Module Assignment

1. By using the term *buoyant force* explain why a toothpick floats in water, but a rock sinks. (4 marks)

   A toothpick floats in water because the ***buoyant force*** *of the water on the toothpick (when submerged) is greater than the weight of the toothpick. The rock sinks in water because the* ***buoyant force*** *of the water on the rock is less than the weight of the rock.*

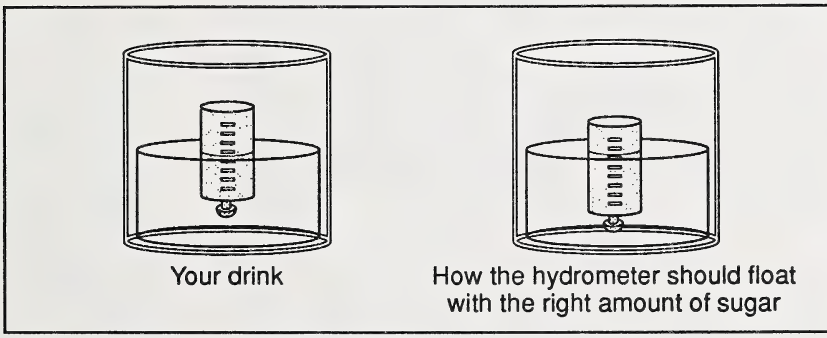
2. Which of the following statements is always true? Explain your answer. (4 marks)

   Vegetable oil is lighter than water.
   Vegetable oil is less dense than water.

   "Vegetable oil is lighter than water" is a statement that is not always true. It means that the weight of oil that is present is always less than the weight of the amount of water that is present. But it may not always be the case. For example 1000 L of vegetable oil is heavier than 0.1 L of water. The volume of fluid is not considered in the statement.

"Vegetable oil is less dense than water" is a statement that is always true. It means that with equal volumes of the two liquids, the vegetable oil always has less mass. Volume is very important to the meaning of this statement and is taken into account by the use of the term dense.

3. You want to check to see if you have put enough sugar in the flavoured drink you have made, so you use a hydrometer that you have calibrated. You find that it floats higher in the drink than it would if you had put the right amount of sugar in.



Did you put in too much sugar or too little? Explain your answer. (4 marks)

If the hydrometer floats higher than it should, the drink is denser than it should be, meaning that too much sugar was put into the drink. The hydrometer floats higher because the buoyant force is greater than it should be. Denser fluids exert greater buoyant forces. So, the drink is denser than expected because it has too much sugar.

4. Apply what you have learned in this module, as well as your general science background, to answer this question as completely as possible.

You are designing a pipeline to carry a fluid across Canada.

a. What are some of the properties of the fluid that you need to know in order for the system to have a safe and efficient design? Explain your answer. (5 marks)

You should know the viscosity, melting and boiling points of the fluid, the corrosiveness of the fluid, and the environmental impact of the fluids. The viscosity is important because you need to know the force needed to pump the fluid through the pipeline. The boiling point and freezing point are important because freezing of the fluid would plug up the pipelines and boiling may cause the pipeline to burst. Corrosiveness will determine what sort of materials you will use to make the pipeline because you want to reduce corrosion to a minimum. The environmental impacts are important so you can put in safety tolerances and emergency plans in case of accidents with the fluid.

b. What are some of the things that you need to know about where the pipeline is going in order for it to have a safe and efficient design? Why? (3 marks)

You need to know the climate of the areas so as to design the pipeline to withstand the temperatures and the terrain that the pipeline is to cross. Climate is important because some fluids change their properties at very low or very warm temperatures. This will determine the pipeline size and whether you are going to heat or cool the fluid during transport. Pump locations will depend on the location of hills.

SCIENCE 9

Module 3

Heat Energy: Transfer and Conservation

LEARNING FACILITATOR'S MANUAL

Distance Learning

Alberta EDUCATION

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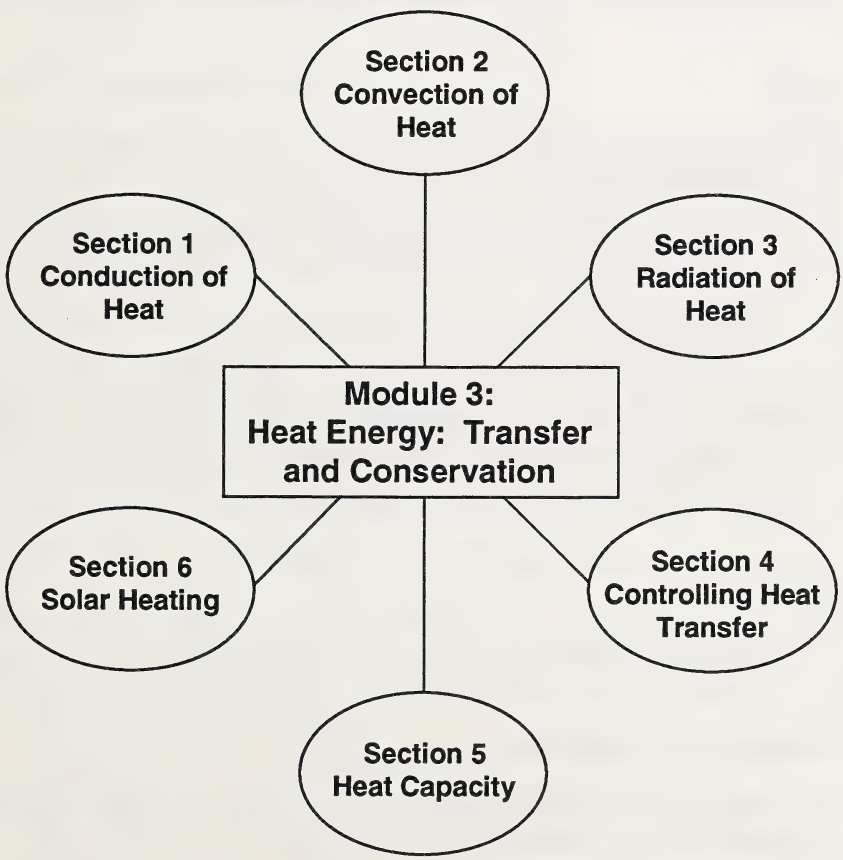
Module 3 – Heat Energy: Transfer and Conservation: Overview

The major emphasis of this module is science and technology.

This module is designed to help students understand how technology can be used to control the movement of heat energy. Students begin by looking at each of the three ways that heat can be transferred. This information will be employed while constructing and testing devices to control the transfer of heat. Another section deals with the fact that different substances warm up at different rates. The final part of the module is about solar heating and related technologies that help to conserve energy resources.



Classroom Opener

Control of the transfer of heat is very important to humans and many other living things on the earth. Why is this so?

Read page 118 in *Science Directions 9* to find the answer to this question. Examine the pictures on page 119 of *Science Directions 9*. How is heat being managed to improve conditions for living things?

Students may identify some of the following: warm clothing, wood stoves, radiant heaters, fire-resistant suits or space-suits, greenhouse environments, migration patterns of waterfowl and feathers for insulation, and the adaptation of boreal forests to temperature climates.

Read the overview in the student booklet with your class as an introduction to this module.

Media

Videocassettes may be available from your regional media centre. If not, contact the ACCESS Network for more information.

The following video resources have been included in a pathway in this module.

- *Eureka: Conduction*
- *Eureka: Convection*

Caution: You may wish to preview the video *Eureka: Conduction* before having the students use it to complete the optional video pathway using this resource, as witches are presented to illustrate conduction.

The following video, although not directly incorporated in any pathways of this module, may also be useful:

- *The Greenhouse Effect*

Materials and Equipment

The materials and equipment are listed under each activity. In planning for the acquisition of the required materials and equipment, you may find it useful to preview these lists.

Some lists will have sub-lists for Part A and Part B. This reflects pathways in the Student Module Booklet. Materials and equipment will be needed for either Part A or Part B, but not for both.

Evaluation

The mark in this module will be determined by students' work in the Assignment Booklet. Students must complete all assignments. In this module students are expected to complete six section assignments.

The assignment breakdown is as follows:

Section 1 Assignment	**10%**
Section 2 Assignment	**10%**
Section 3 Assignment	**10%**
Section 4 Assignment	**25%**
Section 5 Assignment	**20%**
Section 6 Assignment	**25%**
TOTAL	**100%**

Section 1: Conduction of Heat

This section is about conduction, one of the ways that heat can move. Students will investigate whether all solids conduct heat equally. They will use the particle theory to explain the mechanism by which heat is conducted. They will also explore the differences between heat and temperature. Later, they will investigate water as an example of heat conduction in fluids. Students will then test their understanding of heat conduction by trying to solve a number of practical problems.

Alberta students should already have encountered several concepts that will serve as background knowledge for this module. In particular, students should be aware that there are many forms of energy, including light, mechanical, electrical, nuclear, and others. Students should also realize that the forms of energy can be converted from one to another and the total amount of energy is always conserved. The Particle Theory of Matter, which is reviewed on page 62 of the Grade 9 textbook, is used to help students understand how energy affects atoms and molecules. If the student has not previously been exposed to the Alberta STS Science curriculum, some review of these concepts may be needed.

Caution: Any open flame is hazardous! Review the sections called Handling a Heat Source and Rules for Using an Open Flame on pages xiii and xiv at the beginning of the textbook. Safety glasses or other eye protection should always be worn when using a heat source. An electric heat source may be substituted where appropriate.

Section 1: Activity 1

Students may do either Part A or Part B.

The following materials are needed for this activity:

Part A

- safety glasses
- glass rod and a steel rod having the same length and diameter
- two support stands
- two clamps
- heat source such as a gas burner, alcohol burner, or candle
- timing device (minutes and seconds)
- conductometer

Part B

No equipment or materials are needed.

Comment:

The purchase of a conductometer is recommended if this activity will be repeated with a large number of students. Alternatively, 3 mm or 5 mm welding rods made of several different metals can be purchased and cut to size. The procedure must then be modified to suit these materials.

Students should be monitored during performance of the investigation to see that they are recording their data correctly.

1. Which material allows heat to be transferred through it most easily, wood or metal? How can you tell from the drawing of the boy and girl?

   Students should deduce from examining the drawing and reading the text that the answer is metal. The reaction shown by the girl in the picture indicates that the metal spoon is hot.

2. What is the problem for this investigation?

   Students may copy the problem from page 121 of the textbook or reword it to say that this investigation is done to compare the abilities of various solids to conduct heat.

3. Rank the list of materials as directed.

   The ranking predicted by the student will depend on previous knowledge and experience. Wood should be low on the list if the student responded correctly to the question about the spoons (question 1).

4. The beads of wax all melted on the rod made of ___*metal*___ and there were ___*several (1 to 5)*___ beads of wax left on the other rod; therefore, the rod made of ___*metal*___ was the better conductor of heat.

If the student placed the rods equally into the flame, the wax beads should melt completely down the length of the steel rod, while there should still be solid wax beads on the glass rod. The number of beads left on the glass rod will vary.

5. Record the melting times for the wax beads on each rod.

Comment: If the names of the metal rods cannot be determined either from the rods themselves or from materials which accompany them, then other descriptive terms can be used. For example, "gold coloured" or "dull white metal" may be used as long as the terms discriminate between the metals used.

Times will vary with the size of the flame, distance to the flame, and length and diameter of the metal rods. A sample relative order for the metals commonly used, from most conductive to least conductive, would be copper, aluminum, brass, nickel, and iron or steel. The beads on the nickel and steel rods take much longer to melt than those on the first three. The student's data should reflect this order and the time lag for the last two metals, but it is not essentially incorrect if another order is observed. If time allows, the procedure could be repeated to confirm the data.

Metal	Time for Wax to Melt (in seconds)
copper	*42*
aluminum	*49*
brass	*83*
iron	*146*
stainless steel	*152*

6. Based on these observations, what inferences can you make about the abilities of metal, glass, and wood to conduct heat?

Metal conducts heat (coldness) better than glass. Wood is the poorest conductor of heat (coldness).

7. Describe an experiment that could be used to test your inferences. Be sure to include how you would control the variables, such as the thicknesses of the materials being tested.

Answers will vary, but should include the use of three materials (glass, metal, and wood) in a standard size (thickness or length). A standard heat source should be used. A common method of detecting heat, such as melting wax beads or using a thermometer, should be mentioned.

8. Use the information from the preceding diagram to fill in the following chart.

Metal	Time for Wax to Melt (in seconds)
copper	*44*
aluminum	*49*
brass	*83*
iron	*146*
stainless steel	*152*

The above results are only valid for Part B of this investigation and may be different for Part A, depending on the equipment and heat source used.

9. Do question 2 of Analysis on page 122 of your textbook.

The answers here should correspond to the data that was collected. A sample relative order for the metals commonly used, from most conductive to least conductive, would be copper, aluminum, brass, nickel, and iron or steel.

10. Do question 4 of Further Analysis.

There can be any number of answers, but some examples could include the following household items:

- *An electric iron has an electrical element inside to produce the heat which is transferred through the bottom and onto the clothes.*
- A hot-water bottle allows the heat of the water inside to pass through the walls of the container.
- *A Thermos™ bottle keeps the heat in the food which is contained inside.*

Section 1: Activity 2

1. Look at the weather map in the picture at the top of page 122. The numbers recorded on the map are used to describe how hot or cold the air is at various locations.

   a. What do we call these measurements?

      We describe how hot or cold a substance is by its temperature.

   b. What instrument is used to measure how hot or cold a substance is?

      We use a thermometer to measure temperature.

2. How does the motion of cold particles differ from the motion of hot particles?

   Cold particles move more slowly than hot particles.

3. Why will individual particles of a substance be moving at different speeds instead of all moving at the same speed?

   Each individual particle may have a different amount of energy. This will cause the individual particles to move at different speeds.

4. The ___*speed*___ (speed, size, colour) of a particle indicates its ___*energy*___ (heat, energy) level.

5. Temperature measures the ___*average*___ (average, total) speed of many particles, or their ___*average*___ (average, total) energy level.

6. In your own words, what is the definition of *temperature*?

   Temperature is a measurement of the average energy of the particles in a substance. The student's answer should be similar. Example: Temperature measures the energy of particles.

7. In your own words, what is the definition of *heat*?

   Heat is energy that is transferred due to a difference in temperature. Students may add that heat moves from a warmer object to a colder one. Their answers may give concrete examples. Example: Heat is the energy that goes from a hot flame to a pot of cold water.

8. What do the little yellow characters in the first comic strip represent?

The little yellow characters represent particles of matter.

9. Do all four yellow particles move at the same speed? Explain your answer.

No, each particle moves at a different speed. This is because each one has a different amount of energy.

10. Why is the temperature the same whether there are four or eight yellow particles?

The temperature is the same because the average energy of the particles is the same.

11. a. Would water that is 15°C feel warm or cold to your hand if your skin temperature is 20°C?

    The water would feel cold.

    b. Does heat move from your hand to the water, or from the water to your hand?

    Heat moves from your hand into the water, resulting in a sensation of coldness in your hand.

12. If an ice cube is dropped into a cup of coffee, would heat be transferred from the ice to the coffee or from the coffee to the ice?

Heat would go from warm to cold, or from the coffee to the ice cube.

Section 1: Activity 3

The following materials are needed for this activity:

- safety glasses
- large test tube with wax bead at the bottom end
- water at room temperature
- support stand with test tube clamp or a hand-held test tube clamp
- heat source (gas burner or candle)
- thermometer

1. Describe the conduction of heat through a metal rod that is being heated at one end. Be sure to explain what the particles are doing.

   When energy is added to the particles of a substance, they begin to move more rapidly, so the metal particles at the end being heated are speeded up. As those particles bump into other particles, the energy is transferred from one to another and the heat passes along the metal rod.

2. What term describes substances, such as metals, that readily allow heat to transfer through them?

   Substances that readily allow heat to transfer through them are known as heat conductors.

3. What is the problem for this investigation?

   Is water a good heat conductor? The students may put this in their own words to say that water is being tested to see if it conducts heat.

Comment: The student should be monitored during the investigation to see that the data is being correctly taken and recorded. The temperature should rise, but not rapidly. The wax bead will not melt unless the tube is heated for a longer period of time.

4. Read step 1 of the procedure and make your prediction.

   Any response that the student makes is acceptable as long as a prediction about the ability of liquids to conduct heat is given.

5. Record your data in the following chart.

Heat Conduction in Liquids

Time (minutes)	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	*22*	*24*	*27*	*30*	*32*	*35*	*39*	*42*	*46*	*49*

6. Compare your results with your prediction and then answer question 1 of Analysis.

   Answers will depend on the prediction made in question 4. The liquid does not conduct very well and the student's response should reflect this.

7. Think about how heat is conducted through a solid and then answer question 2 of Analysis.

   Because the temperature of the water at the bottom of the tube does not change very quickly, it may be inferred that the particles of water do not collide with each other as much as the particles in a solid. Water is a poor conductor of heat, as compared to metal.

8. Keeping in mind that a substance that is a non-conductor would not transfer any heat, answer question 3 of Analysis.

   Because some heat conduction is indicated by the rise of temperature at the bottom of the tube, liquids are more like metals than non-metals in terms of heat conduction.

9. Consider the spacing of particles when you answer question 5 of Further Analysis.

   Gases are most likely poor conductors of heat. The particles in a gas are farther apart than in solids or liquids; therefore, they probably will not bump into each other very often. On the other hand, gas particles are very energetic and the student could therefore reason that gases should be good heat conductors.

10. In the last question of the investigation you just completed, you made a prediction about the conductivity of gases. Were you correct? Explain your answer.

    Responses will depend on the prediction made in question 9. For example, if the student predicted that gases should be poor conductors, then the fact that Table 3-1 shows air to be a poor conductor supports that prediction.

11. Arrange the following items in proper order from greatest to least thermal conductivity: brick, air, copper, and water.

    Using Table 3-1 to obtain the ratings, the order should match the following list.

    copper greatest

    brick

    water

    air least

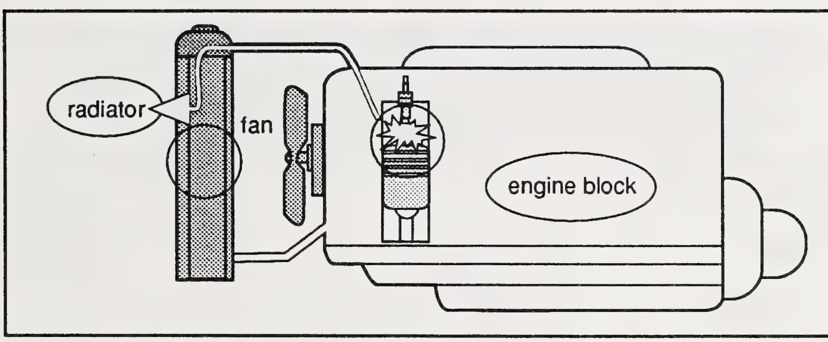
12. The substance from Table 3-1 through which heat is most easily transferred is *silver*. Its thermal conductivity is rated as *18 000* compared to air.

Section 1: Activity 4

1. If human skin and tissues were very good heat conductors, it would be dangerous to leave heating pads or cold packs on your body for very long. Explain why.

   If human skin and tissue conducted heat very well, a heating pad would cause overheating in a short time and a cold pack would cause extreme cooling of the flesh. Either could cause damage to the person's body.

2. Put arrows on the following diagram to show the path that heat takes in the cooling system of an automobile. Begin where the explosion of the fuel in the engine converts chemical energy into heat and motion. Circle two places where conduction occurs.



3. What metal would be a poor choice for the material from which to make an automotive radiator? Give your reason.

   Any metal with a low conductivity would be a poor choice for radiator material. Students may have listed iron, steel, or brass from Table 3-1 in the text.

Section 1: Follow-up Activities

Extra Help

Students may do either Part A or Part B.

Caution: You may wish to preview the video *Eureka: Conduction* before having students use it to complete the optional video pathway for Part A, as witches are presented to illustrate conduction.

1. Explain how the behavior of the dominoes shown in the video demonstrates conduction?

   As energy is given to the first domino, it begins to move, much like particles of matter. When the domino collides with another, it has the effect of increasing the motion of the one it hits by transferring energy to it. In this way energy is conducted down the line of dominoes.

2. What must a material do in order to be called a good conductor?

   A material must allow heat to transfer through it in order to be called a good conductor.

3. Why are metals such good conductors?

   Metals are good conductors beause of the large number of free electrons allowed to move within them.

4. Use the words from the following list to correctly fill in the blanks in the paragraphs. Each word will be used once.

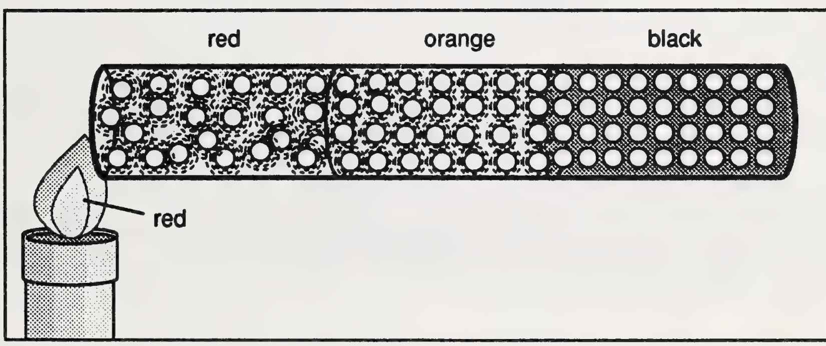
   vibrate
   less
   transferred
   quickly
   conduction
   energy

   Knowing how heat moves from one place to another helps you control heat. One way that heat can be transferred from place to place is by ___*conduction*___. Conduction happens when a moving particle with lots of energy collides with a slower particle with ___*less*___ energy. Bumping into the slower particle transfers ___*energy*___. This speeds up the motion of the slower particle.

   Imagine two people walking down the street towards each other and bumping into each other. They are both going to get a little shaken up. Now imagine that one of them is running. If they collide, a lot of energy is going to be transferred!

Particles of matter behave in a similar fashion. A hot particle which has picked up heat energy from a heat source such as a flame begins to vibrate very *quickly*. When it collides with another particle, some energy will be *transferred*. The second particle will start to *vibrate* more quickly too. You can see this illustrated in the diagram at the bottom of page 124 in the textbook.

5. In the space below, draw and colour a picture that is similar to the one on page 124 in the textbook. Your picture should show the particles vibrating in the solid rod. It should also show how energy (heat) is passed from one particle to the next. Colour your flame red to show lots of heat. The end of the rod that is in the flame should be red as well. Colour the middle of the rod orange to show that it is heated up a bit. The end farthest from the flame should be coloured black to show that it is still cool.



6. In your own words, explain how the heat would travel along the rod in your drawing.

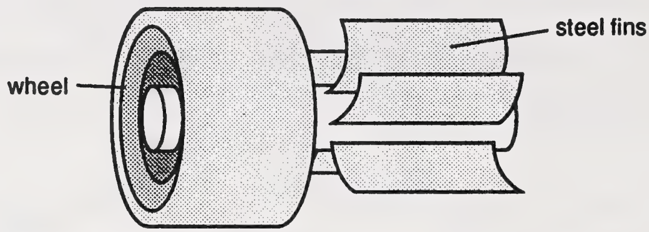
   Students should describe that the particles are moving due to energy and that the particles at the hot end are getting more energy and are therefore moving more quickly. The increased motion leads to collisions which cause energy to be passed along from particle to particle.

Enrichment

Students may do either Part A or Part B, or both.

1. Think of another situation where conduction of heat might prevent a fire or explosion, keep someone from burning themselves, or maybe provide heat to keep something from getting too cold. Come up with an invention to save the day in one of these situations. In the space provided, draw a simple diagram of your invention and give a brief explanation of the situation and how your device works.

   Answers will vary widely. The key thing to evaluate is whether the student shows an understanding of the role that conduction plays in the device that is suggested.



Sample

   An example would be the specially designed skateboard wheel shown above. It has an axle made of a highly conductive metal (silver) and has fins to conduct the heat to the air, like a radiator. Effective heat transfer could prevent softening or melting of the wheel when rapid revolutions cause a lot of friction which heats the wheel.

2. Do questions 5, 6, and 7 on page 135 of your textbook.

   Textbook question 5. (a):

   The copper bottom of the pot will quickly transfer the heat from the stove element because copper has a high thermal conductivity. The steel sides and lid are not as conductive and will not tend to transfer heat away from the pot as readily as copper would. Heat is therefore held in the pot.

   Textbook question 5. (b):

   The plastic handle of an iron is not very conductive and does not allow much heat to be transferred to a person's hand.

   Textbook question 5. (c):

   The highly conductive metal transfers more heat into the potato than there normally would be. This causes the potato to cook more quickly.

Textbook question 6:

If air was highly conductive, large amounts of heat would be transferred away from your skin, making you feel cold.

Textbook question 7:

Although a dry sponge does contain some solid material, it is mostly full of air, which is not a very good conductor.

Section 1 Assignment

Marking Guide:
Short answer questions – award one mark for each point of information required by the question.

Suggested values are shown in brackets.

1. Using the particle theory, describe the difference between heat and temperature. (2 marks)

   The response should include the definitions of heat and temperature that involve the particle theory. Heat is energy being transferred from one particle to another; while temperature is a measurement of the average energy of all the particles in an object.

2. During a lab investigation, students placed a brick in a hot oven and left it for 30 minutes. Use the particle theory to describe what the effect would be on the particles all the way through the brick. (4 marks)

   The following elements should be present in the response:

   - *The particles on the outside of the brick gain energy and speed up.*
   - *Collisions with interior particles conduct energy to them.*
   - *The interior particles speed up.*
   - *The average energy of the particles has risen, causing the temperature of the brick to rise.*

3. A builder wants to make a wall that will transfer heat well so that heat from one room will transfer through into another. Either brick or concrete can be used. Which material would you recommend? Explain how you made your decision. (2 marks)

   Using Table 3-1, the student can find out that concrete would be the best choice because it has a higher thermal conductivity than brick.

4. Which pan would cook scrambled eggs faster, one made of iron or one made of aluminum? Explain your answer. (2 marks)

   The answer should include the proper choice, which is aluminum, along with the information that aluminum has a higher thermal conductivity rating and, therefore, will conduct heat to the eggs more quickly.

Section 2: Convection of Heat

Convection is another way that heat can be transferred. By investigating convection in fluids, the student will discover the convection currents that exist in the natural world and be able to explain why they occur.

Caution: Any open flame is hazardous! Review the sections called Handling a Heat Source and Rules for Using an Open Flame on pages xiii and xiv at the beginning of your textbook. Safety glasses or other eye protection should always be worn when using a heat source. An electric hotplate may be substituted whenever available and applicable.

Section 2: Activity 1

Students may do either Part A or Part B.

The following materials are needed for this activity:

Part A

- safety glasses
- cold water
- large beaker
- support stand
- large ring clamp
- small ring clamp
- coloured chalk dust or ice cubes containing food colouring
- heat source

Part B

- safety glasses
- heat resistant (Pyrex™) coffee pot or similar container
- heat source such as a stove burner
- non-flammable support for the unheated side of the pot
- coloured chalk dust or coloured ice
- cold water

1. What is the problem for this investigation?

   When heat is applied to one area of a container of water, how does it transfer to the rest of the water in the container? The students may have reworded the problem to say that heat transfer in liquids is being investigated.

2. Describe the movement of the water directly above the heat source.

   The movement of the chalk dust or ice should show an upwards movement above the heat source.

3. What do you see happening in the beaker that indicates that there is not only upward movement in the water?

   If there is a rising over the heat source, a falling of cooler water may be visible on the other side of the beaker. Lateral movement may be visible at the top and bottom of the beaker.

   Example: I see the chalk moving across the top of the beaker and then down.

4. Give an example of something you have observed elsewhere that makes you think that the type of movement you have seen in water can also occur in air.

   Answers may vary widely. Heat waves shimmering above a hot roadway or above an object such as a car show this. Smoke rising from a fire, being able to feel the heat above a heat source better than below it, and discoloration of the wall above a hot air vent, and not below it, are also examples.

Section 2: Activity 2

1. Use the particle theory of matter to describe and explain the movements you observed in the water in the previous investigation.

   Particles directly above the heat source gain energy and start moving more quickly than before. They spread out and push other particles away, causing that area of the fluid to become less dense. The warm, less dense fluid rises and is replaced by cooler, more dense fluid. This causes a complete current to form.

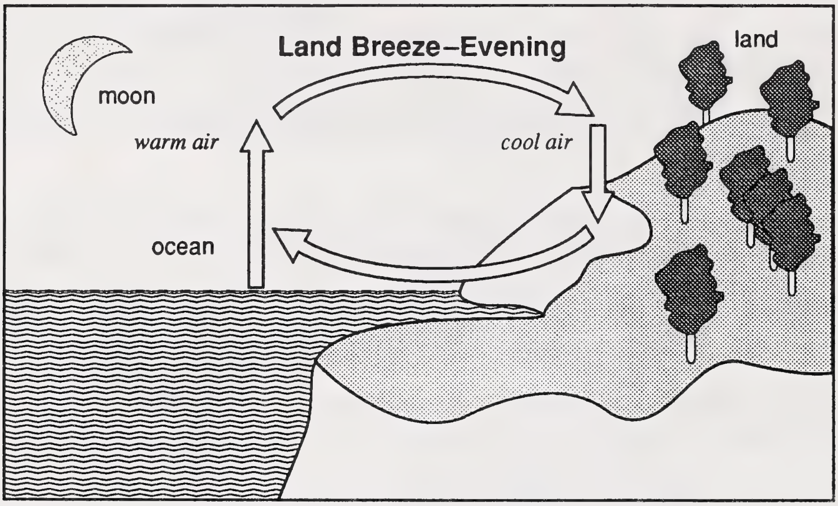
2. Why can convection not occur in a solid?

   The particles of a solid are not free to flow.

3. What is the main difference between conduction and convection?

In conduction, the particles are stuck in place and heat is transferred from one particle to another. In convection, the particles are free to move and carry the heat along with them.

Section 2: Activity 3



1. On the preceding diagram, label the places where the warmest and coolest air would be found.

   See the preceding diagram for where the warmest and coolest air would be found.

2. Draw arrows on the preceding diagram to show the movement of air in a complete convection current.

   See the preceding diagram for the movement of air in a complete convection current.

3. Describe another example of convection in nature, other than land and sea breezes, that is discussed in the textbook.

   The student could use either thermal updrafts or the earth's magnetism as an example. As cool ground is warmed by the rays of the sun in the morning, the air above the ground is warmed and rises to form thermals. Soaring birds and hang-gliders make use of these updrafts for flight. The convection of materials in the earth's outer core is thought to be responsible for the magnetic field. Temperature differences within the liquid outer core result in these movements and, since there is molten iron containing charged particles, a magnetic effect results.

Section 2: Follow-up Activities

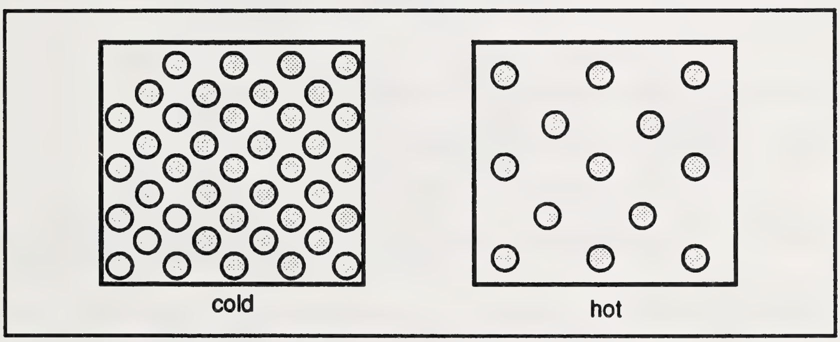
Extra Help

Students may do either Part A or Part B.

1. In a home heating system, why is the furnace in the basement?

   Since hot air rises, placing the heat souce in the basement uses the natural formation of a convection current to transfer heat throughout the house and bring cool air to the furnace.

2. In the following boxes, draw circles to represent particles of matter. Show how the particles are spaced differently in hot and cold fluids.



3. What name is given to the tendency of less dense objects to float on top of more dense objects?

   *The video uses the term **buoyancy** to explain what causes convection.*

4. Use the words from the following list to correctly fill in the blanks in the following paragraphs. Each word will be used once.

energy	more
warmer	convection
solids	conduction
fluids	convection current

Conduction is a good way for heat to move in ____*solids*____. In fluids ____*conduction*____ does not work very well. Instead, in both liquids and gases, ____*convection*____ occurs. Because the particles of ____*fluids*____ are free to flow, they tend to move around, rather

than vibrate in place and pass their energy to their neighbours. When a fluid gains _____*energy*_____, the particles near the heat source begin moving more rapidly and spread out as they collide more often, pushing each other away.

This makes the fluid less dense where the _____*warmer*_____ particles are found. The less dense parts of the fluid tend to rise above the _____*more*_____ dense parts. This rising of one part and falling of another sets up a _____*convection*_____ _____*current*_____.

5. Why are the particles in a hot fluid farther apart than the particles in a cold fluid?

   As the particles in a fluid become warm, they gain energy and their motion increases. This causes them to collide more often, pushing each other away.

6. If hot gas is released into a room, will it tend to go up or down?

   A hot gas would go up when released into a room.

7. When you open the refrigerator door, does the cold air that escapes tend to rise or fall?

   Cold air tends to fall.

Enrichment

Students may do either Part A or Part B, or both.

The following materials are needed for this activity:

Part A

No equipment or materials are needed.

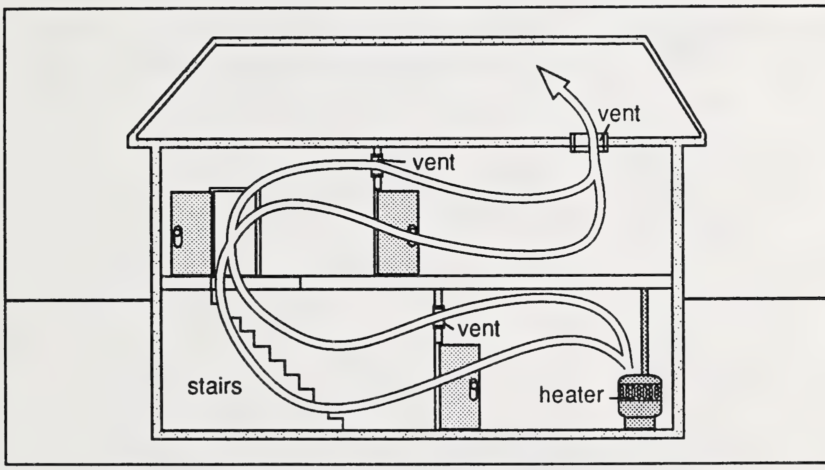
Part B

- cardboard box
- five thermometers
- electric light bulb (60 W) and receptacle
- metal foil or suitable lampshade
- timing device

Comment: Part B needs to be a group activity for four to six students. Care must be taken to read the thermometers carefully, record accurately, and then plot the graph properly. A review of graphing can be found on pages 354 to 358 in the textbook, but the essential points are found on page 356.

1. Sketch out a plan for a house like the one described. You may wish to include vents, staircases, windows, and doors to influence the flow of air.

   Example: More detail is acceptable.



2. What is the problem for this investigation?

   How can you observe heat transfer through air? The student may reword the problem to say that heat transfer in air is being investigated.

3. Record your observations in the following chart.

   Sample data.

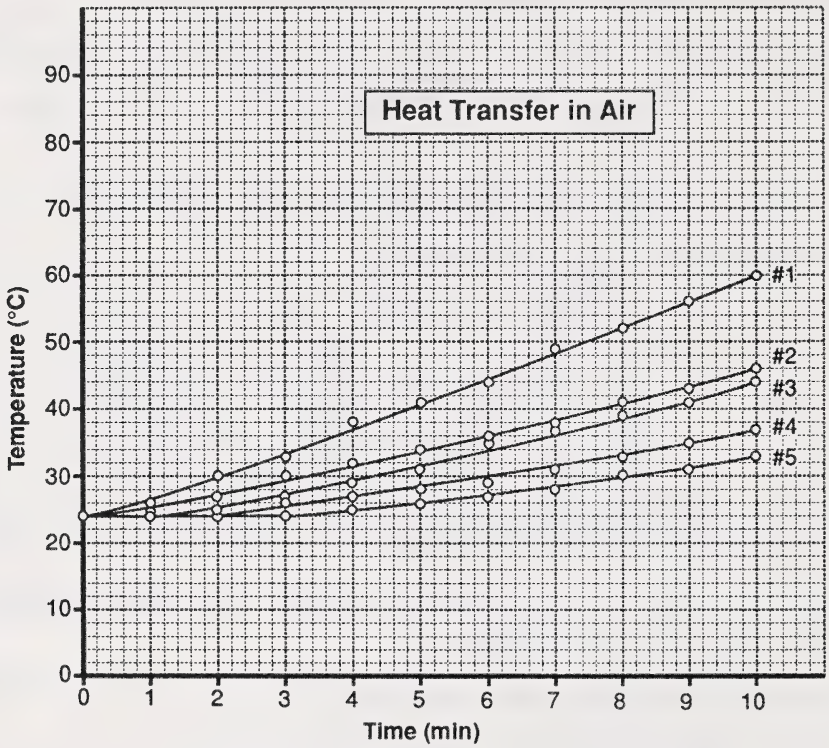
Heat Transfer in Air

Time (min)	0	1	2	3	4	5	6	7	8	9	10
Temp. #1 (°C)	*24*	*26*	*30*	*33*	*38*	*41*	*44*	*49*	*52*	*56*	*60*
Temp. #2 (°C)	*24*	*25*	*27*	*30*	*32*	*34*	*36*	*38*	*41*	*43*	*46*
Temp. #3 (°C)	*24*	*24*	*25*	*27*	*29*	*31*	*35*	*37*	*39*	*41*	*44*
Temp. #4 (°C)	*24*	*24*	*24*	*26*	*27*	*28*	*29*	*31*	*33*	*35*	*37*
Temp. #5 (°C)	*24*	*24*	*24*	*24*	*25*	*26*	*27*	*28*	*30*	*31*	*33*

4. Do question 3 in Analysis.

Textbook question 3. (a):

Sample Graph



Textbook question 3. (b):

The curves on the graph indicate that the heat tends to rise, since the temperature on the thermometers located at the top of the box show the quickest increase.

Section 2 Assignment

Marking Guide:
Short answer questions – award one mark for each point of information required by the question.

Suggested marks are shown in brackets.

1. Compare conduction and convection using the particle theory of matter. (4 marks)

   Conduction occurs in solids, where the particles are held in position and energy must be passed along from one particle to another. Convection occurs in fluids, where the particles are free to flow and energy can be carried from place to place by a particle.

2. If you were designing a home that would be heated using electric heaters, would it be better to place them near the roof or near the floor? Explain your reasoning. (2 marks)

   Electric heaters would be best near the floor because the heat can rise through the room and mix with the cooler air as it rises.

3. Do question 11. (c) on page 135 of the textbook. (2 marks)

   Leaving the vent covers on would allow the cool air to stay near the floor. Removing the covers will blow the air up to mix with the warmer air in the upper part of the room.

4. Explain how the atmospheric convection current known as a thermal is formed. A diagram may be included as part of your answer. (2 marks)

   When the sun shines on the ground and warms it, the air above the ground is also warmed. This causes the air to become less dense and start to rise.

Section 3: Radiation of Heat

This section deals with radiation, the third way that heat can be transferred from one place to another. After discovering the special nature of radiant energy and looking at the spectrum of energy waves, students will investigate how radiation and matter interact. Studying the properties of radiant energy will help students to use technology to control the radiation of heat.

Section 3: Activity 1

The following materials are needed for this activity:

- two or more metal containers with opposite types of surfaces, for example, dark vs. light-coloured or shiny vs. dull texture (Soft drink or juice cans painted different colours or covered with paper of different colours will work well.)
- thermometer for each container
- 200 W lamp or flood lamp (A 100 W lamp may be used if a 200 W lamp or flood lamp is not available.)
- timing device
- cotton batting or plasticine

The containers should be identical except for their colour and/or texture, which should be dramatically different. Painting the cans different colours is preferable to using coloured paper, as there can be a fire hazard if the paper sits too close to the light bulb.

Comment: Before students complete this investigation they should review the graphing of scientific data, starting on page 354 of their textbook. A review of the steps for making a graph is given on page 356.

1. Name four different forms of radiant energy.

   Students could have listed any of the forms shown on the spectrum in the textbook, including radio waves (long wave, AM, FM, TV, or radar), microwaves, heat waves (infrared radiation), visible light, ultraviolet light, X rays, and gamma rays.

2. The complete range of forms of radiation can be called a ___*spectrum*___.

3. Radiant energy is transmitted as waves. Different types of waves have different amounts of energy. The lowest energy waves in the spectrum are ___*radio*___ waves and the highest energy waves are ___*X rays or gamma rays*___ rays. The most dangerous waves are the ___*highest*___ energy waves.

4. As a method of heat transfer, how is radiation different from conduction and convection?

   Both conduction and convection require particles of matter, but radiation transfers energy as waves and can travel through a vacuum.

5. What is the problem for this investigation?

   How are different types of materials affected by heat and light? The student may have reworded this. Example: The problem is to find out which will heat up faster, a black can or a silver can.

6. Make a prediction about what will happen to the temperatures in the containers over 10 minutes. Will the containers have the same warming pattern?

   The student should predict which container will heat up faster or state that the containers will heat up at the same rate. Example: The black can will show a greater change in temperature than the silver can.

7. What is the manipulated variable in this investigation?

   The manipulated variable in this investigation is the colour of the container.

8. What is the responding variable in this investigation?

   The responding variable in this investigation is the temperature of the air inside each container.

9. Record the temperatures of your samples in the following chart.

   Measure and record the initial temperatures in the containers and turn on the lamp. Measure and record the temperatures every minute for 10 minutes.

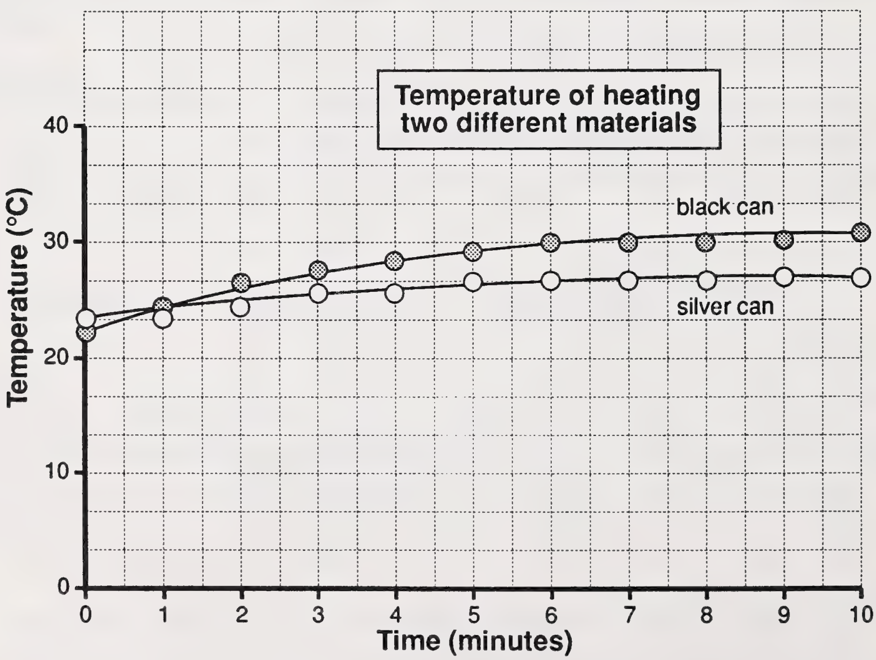
   Sample data:

Time (minutes)	Temperature in Black Can (°C)	Temperature in Silver Can (°C)
0	*22*	*23*
1	*24*	*23*
2	*26*	*24*
3	*27*	*25*
4	*28*	*25*

Time (minutes)	Temperature in Black Can (°C)	Temperature in Silver Can (°C)
5	*29*	*26*
6	*30*	*26*
7	*30*	*26*
8	*30*	*26*
9	*30.5*	*26.5*
10	*31*	*26.5*

10. Do step 5 of the procedure using the grid provided.

Check to see that the student's graph matches the data that the student gave in the chart for question 9. Following is a graph using the sample data used for question 9.



11. Do questions 1, 2, and 3 of Analysis on page 137 of your textbook.

Textbook question 1. (a):

When light rays strike a dark surface they seem to be absorbed more.

Textbook question 1. (b):

When light rays strike a bright shiny surface they seem to be reflected more.

Textbook question 2:

The factors that influence how well light is absorbed or reflected are colour and texture of the surface. If the student tested colour, they might not state surface texture. The same holds true if they tested texture.

Textbook question 3:

When a material absorbs radiant energy, the average energy of the particles of the material increases, causing the temperature to rise.

Section 3: Activity 2

1. When radiant energy interacts with matter, the waves may be ___*reflected*___, ___*absorbed*___, or ___*transmitted*___.

   In the last investigation, light was ___*reflected*___ by the shiny or white can, ___*absorbed*___ by the dull or dark can, and ___*transmitted*___ by air.

2. What evidence tells us when radiant energy has been absorbed by an object?

   When energy is absorbed, a rise in temperature occurs.

3. Which of the three kinds of interactions of radiant energy with matter results in the greatest gain in energy for the material receiving the radiation? Explain your answer by telling what happens to the energy in all three interactions.

   Absorption results in the greatest gain in energy since the energy is kept by the material. Reflection causes the energy to bounce away from the material, and transmission allows the energy to pass right through the material.

4. What is the usual relationship between an object's ability to absorb radiant energy and its ability to emit radiant energy?

   Generally, good absorbers are also good emitters.

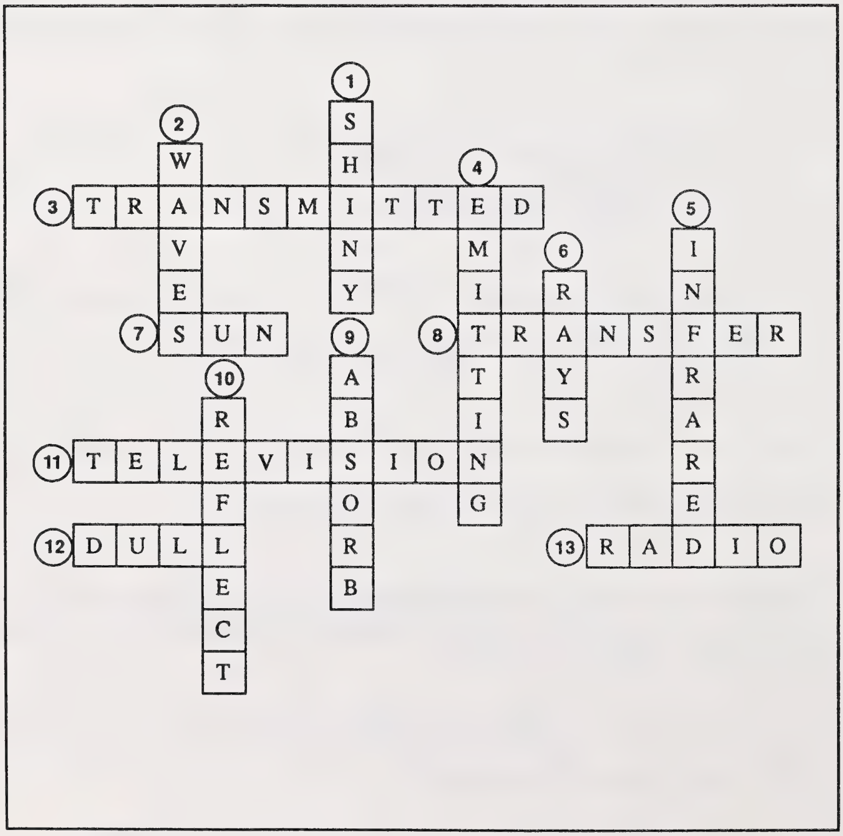
Section 3: Follow-up Activities

Extra Help

1. Use the following word list to correctly fill in the blanks on the crossword puzzle. Each word will be used once.

   Word List

sun	dull	transfer
waves	rays	television
shiny	infrared	reflect
radio	emitting	absorb
transmitted		



2. Think of two examples which involve radiant heat energy and list them in the chart below. Beside each one, state briefly how heat radiation is involved. One example has been done.

Example	How Heat Radiation Is Involved
hot-water heating	hot water in a radiator radiates heat into the room
toaster	*heat rays from wires cook toast*
fox ears	*foxes that live in cold places have smaller ears so they don't radiate as much heat*

Many more examples could be given, including heat emitted by hot asphalt, heat from a fire, energy coming from the sun, polar bear fur and skin, and heating elements and reflectors. A microwave oven would not be an example of radiated heat since the microwaves are not infrared waves.

Enrichment

Students may do either Part A or Part B, or both.

The following materials are needed for this activity:

Part A

No equipment or materials are needed.

Part B

- two or more metal containers with opposite types of surfaces, for example, dark vs. light coloured or shiny vs. dull texture (Soft drink or juice cans painted different colours or covered with paper of different colours will work well.)
- thermometer for each container
- stirring rod for each container
- hot water from a hot water tap
- timing device
- cotton batting or plasticine

Caution: Domestic hot-water heaters are capable of producing water that is hot enough to scald your skin. Remind students to handle hot water carefully and to use oven mitts to handle metal containers with hot water in them. Remember that metals conduct heat very well!

Comment:

The investigation in Part B must be done quite carefully to get good results. The difference in cooling rates may not be very dramatic and the closer the containers are to identical, except for colour or texture, the better. A great difference between the colours and textures is important for good results.

1. Imagine life without any technologies designed to produce and control radiant energy. Write a paragraph describing the ways that your daily life would be different if suddenly such technologies did not exist.

   The student should correctly identify some of the daily conveniences that technology has allowed people to enjoy, but not eliminate the natural sources of radiation. For example, radiation from the sun lights up the daytime, but in order to see at night, the moon would have to be out since no artificial light would exist. You may go so far as to argue that even the ability to make fire is a radiation-controlling technology and, therefore, using fire to see or to warm yourself would be among the lost technologies. To cook food would be less convenient since only conductive or convective means would be allowed. Certainly the student would have to live without a microwave, toaster, or perhaps even a refrigerator, since heat is radiated from the condenser coils in the back. Radios, televisions, satellite communications, including some long-distance telephone links, and medical X rays would also be eliminated. Any other response that can be shown to be appropriate should be encouraged.

2. State the problem for an investigation to find out about the cooling of the same containers used in the previous investigation.

   The problem could be to discover how the colour or texture of a surface affects its ability to emit radiant energy.

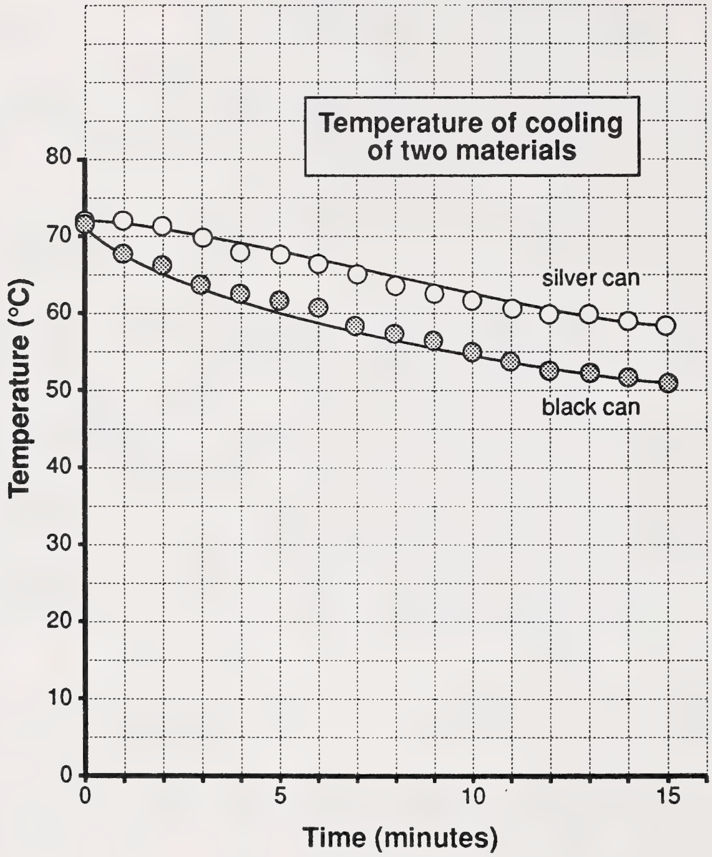
3. Prepare a chart in which to record your data during 15 minutes of cooling.

Answers will vary. The following chart shows some sample data.

Time (minutes)	Temperature in Black Can (°C)	Temperature in Silver Can (°C)
0	*72*	*72*
1	*67*	*72*
2	*66*	*71*
3	*64*	*70*
4	*63*	*68*
5	*62*	*68*
6	*61*	*67*
7	*58*	*65*
8	*57*	*64*
9	*56*	*63*
10	*55*	*62*
11	*54*	*61*
12	*53.5*	*60*
13	*53*	*60*
14	*52*	*59*
15	*51.5*	*58*

4. Plot a graph to show the cooling curves for the containers.

Answers will vary. The values on the graph must match the values shown in the chart to question 3. A sample graph follows.



5. What effect do the different surface colours have on the emission of radiant energy?

The black or dull surface has a slightly greater ability to emit radiant energy and cause the water to lose heat more rapidly than the silver can. If the student's data does not fit this conclusion, then an appropriate one should be stated.

Section 3 Assignment

Marking Guide:
Short answer questions – award one mark for each point of information required by the question.

Fill in the blanks – award one mark for each correct answer to the maximum allowed. Spelling is important.

Suggested marks are shown in brackets.

1. What type of surface could be used to reflect infrared radiation? (1 mark)

   Light-coloured, shiny surfaces are the best reflectors.

2. What property of light makes shadows possible? (1mark)

   Light travels in a straight line.

3. What type of surface would be a good emitter of infrared radiation? (1 mark)

   Dark-coloured, dull surfaces are the best absorbers and, therefore, the best emitters.

4. Name two types of material that transmit light. (2 marks)

   Glass, clear plastic, air, and some mineral crystals, such as gems, all transmit light.

5. To bake a potato wrapped in aluminum foil, should you put the dull side or the shiny side towards the potato? Explain your answer. (2 marks)

   The shiny side should be towards the potato so that the dull side absorbs more heat from the oven. The heat is also kept in by the greater reflection of the shiny side.

6. Explain the roles that reflection, absorption, and transmission play in microwave cooking. A diagram may be used to illustrate your answer. (3 marks)

   Microwaves generated in the oven are reflected off of the stirrer and metal walls of the oven, transmitted by the air and the cooking container, and absorbed and converted to heat by the water in the food.

Section 4: Controlling Heat Transfer

In this section students will use what they have learned about conduction, convection, and radiation. After testing materials for their ability to prevent heat transfer, students will design, construct, and test a heat-control device. Information about insulation and the way the earth is kept warm by its atmosphere will conclude the section. Because the curriculum emphasis for this module is science and technology, this section is particularly significant. The student has now covered the necessary background information to be able to understand the principles used in a heat-conserving container. The first investigation has the student discovering the use of layers of insulating material, and the following investigation has the student designing and constructing a device to conserve heat in a water sample. Encourage the student to refer back to the previous sections for ideas. Confidence in their own ability to solve problems is an objective in this module, so careful guidance in the process of figuring out alternatives and choosing an appropriate plan is required to ensure success. Some assistance in obtaining a wide variety of materials may be needed as well. It is very important that the student actually completes and tests a device.

The student should be made aware of some guidelines regarding the sketches required in the section activities and the section assignment. No special artistic skill is needed. It is the ideas that are expressed in the drawings that will be evaluated. Neatness is important. Simple diagrams are preferable. Drawings should be done in pencil. Using a ruler to draw lines will increase neatness. Labels should be printed neatly and connected to the place that they refer to with a neatly ruled line.

Section 4: Activity 1

The following materials are needed for this activity:

- one or more cardboard boxes (boxes used for photocopy paper are ideal)
- thermometer
- string, tape, and scissors
- timing device
- 60 W or 100 W light bulb and fixture
- two or more materials to be tested: for example, natural cloths such as cotton, wool, or linen; synthetic cloths such as nylon, rayon, or polyester; newsprint; aluminum foil; or commercial insulating materials such as polystyrene and fibreglass
- hot water

1. What is the reason given for our need to develop technology to control heat transfer?

   Conservation of energy resources is necessary so that there are some left for future generations.

2. What are the two problems for this investigation?

   a. *What materials are best for preventing heat transfer?*

   b. *How does a material's thickness affect heat transfer?*

3. Record your data in the chart below.

   Answers will vary. Sample data is shown in the chart.

Control Data for Cooling Box

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C)	*40*	*39*	*38*	*36*	*34*	*33*	*31*	*30*	*29*	*28*	*27*	*27*	*26*	*26*	*25*	*25*

4. Record your data in the following charts. Write the name of the materials being tested in the spaces provided. If you are testing more than two materials, make more charts for your data on a separate sheet of paper.

   a. **Cooling Data for Covered Box**

   material: *A*

   Answers will vary. Sample data is shown in the chart for material A.

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C)	*40*	*40*	*39*	*38*	*36*	*35*	*34*	*33*	*31*	*31*	*29*	*28*	*28*	*27*	*27*	*26*

b. **Cooling Data for Covered Box**

material: *B*

Answers will vary. Sample data is shown in the chart for material B.

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C)	*40*	*40*	*40*	*39*	*39*	*38*	*38*	*37*	*37*	*36*	*36*	*35*	*35*	*34*	*34*	*33*

5. Record your data in the chart below.

Answers will vary. Sample data is shown in the chart.

Cooling Data for Layers of Covering

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C) One layer	*40*	*40*	*39*	*38*	*36*	*35*	*34*	*33*	*31*	*29*	*28*	*28*	*27*	*27*	*27*	*26*
Temp. (°C) Two layers	*40*	*40*	*39*	*39*	*38*	*38*	*37*	*36*	*36*	*35*	*35*	*34*	*34*	*33*	*33*	*32*
Temp. (°C) Three layers	*40*	*40*	*40*	*39*	*39*	*38*	*38*	*38*	*37*	*37*	*36*	*36*	*35*	*35*	*34*	*34*
Temp. (°C) Four layers	*40*	*40*	*40*	*39*	*39*	*39*	*39*	*38*	*38*	*38*	*37*	*37*	*37*	*37*	*36*	*36*

6. Summarize what you have learned from this investigation by answering the questions that were asked in the problem section.

Answers will vary according to the data collected. In the example above, material B is better at preventing heat transfer than material A, and the ability to prevent heat transfer increases with thickness.

Section 4: Activity 2

1. What problem are you asked to solve in this investigation?

   What are the best ways of preventing heat from transferring away from a sample of hot water? (The students may have restated this in their own words.)

2. What materials would you choose to prevent conduction of heat? (Think about what you learned in the last investigation and in Section 1 of this module.)

   The student should give examples of materials with low thermal conductivity, such as air, down, cork, glass, or others from table 3-1 with low values. The student may also name other materials that are known to be poor conductors.

3. What conditions must exist for convection to occur? (Think about Section 2 of this module.)

   There must be a fluid that is being heated in one spot more than others and is free to flow in a convection current. (The student will probably not include this much detail in your response.)

4. How can you discourage heat transfer by radiation from occurring? (Remember Section 3 of this module.)

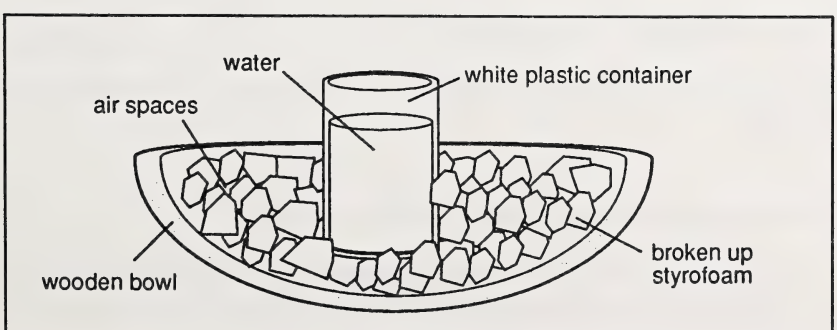
   Reflective surfaces on the inside and outside of a container would inhibit radiation. Direct contact with solid matter would also inhibit radiation, especially if the material is a poor conductor.

5. Make sketches of at least three alternative designs.

   Sketches will vary. It is important that students consider more than one way to prevent heat loss. They do not need to have only three sketches, they may have more.

6. Make a sketch of your selected plan in the space provided.

   Sample answer



7. How much water will you use?

The student is free to select a reasonable amount of water. A sensible amount would be anywhere from 50 mL to 2 L.

8. How long will you allow it to cool?

The student is free to select a reasonable length of time. Up to one class period (30 minutes or so) could be allowed.

9. What changes did you make to your plan while constructing your device? Mention one example of troubleshooting during construction.

Answers will vary. Careful monitoring of progress during the construction phase will allow you to judge the quality of this response. An example would be that the size of the sample had to be made smaller because a large container could not be found.

10. In the space below, make a chart in which you will record your data.

The student is free to design a suitable chart. The following is only a sample.

Preventing Heat Transfer: Sample Data

Time (min)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Temp. (°C)	*65*	*63*	*61*	*59*	*57*	*55*	*54*	*52*	*50*	*48*	*46*

11. How well did you solve the problem?

From the sample data above, the water did lose heat slowly, so the problem was only partly solved.

12. What would you change to make your design even better?

The students should suggest improvements based on their own experience in this activity. From the data above, it could be suggested that a lid be added to the container to prevent convection above the water.

13. Give two examples of how you could conserve energy by using what you have learned in this investigation.

The students should suggest applications such as that all machinery using hot water, such as washing machines, should be lined with styrofoam to prevent heat loss.

Section 4: Activity 3

1. Fill in the following chart. One example has been done for you.

Insulator	Purpose
pink fibreglass	keeps walls from transferring heat
rubber wet suit	*keeps divers warm*
pot holders	prevents burning hands on hot dishes
dead-air space	*keeps windows from losing heat*
down feathers	keeps waterfowl warm

2. What do the letters RSI stand for?

The R stands for resistance to heat transfer and the SI stands for Systéme International, the metric system.

3. Use table 3-2 in your textbook to help you order the following insulating materials from best to worst.

blue polystyrene	brick	plywood
gypsum board	fibreglass	vermiculite

blue polystyrene best

fibreglass

vermiculite

plywood

gypsum board

brick worst

4. Calculate the RSI value of white polystyrene that is 5 cm thick.

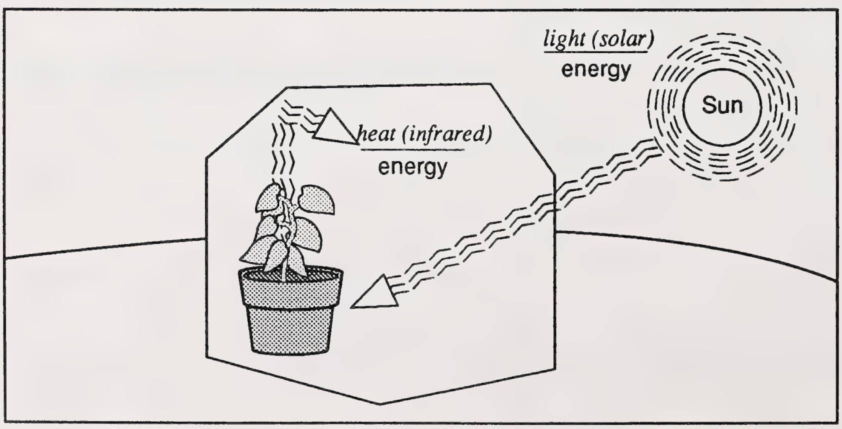
RSI = 0.29 per cm × 5 cm = 1.45

Section 4: Activity 4

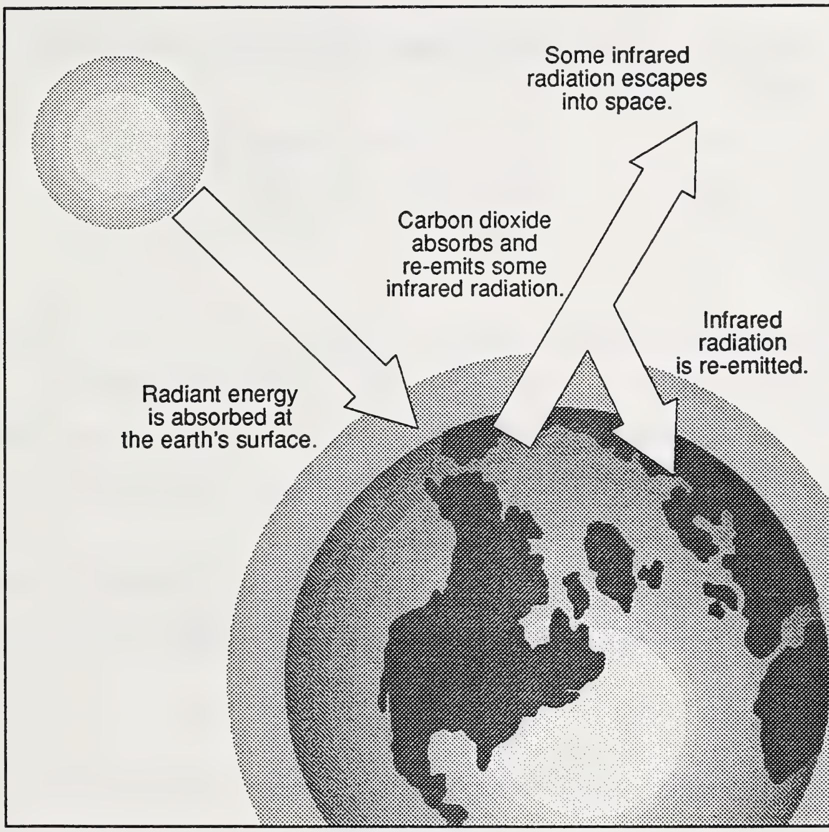
1. Why is the name *greenhouse effect* applied to the phenomenon that maintains a constant temperature on the earth?

The name is suitable because the same thing that happens in the atmosphere happens in a greenhouse.

2. Label the diagram below by filling in the blanks.



3. Draw a diagram of the greenhouse effect in Earth's atmosphere.



4. If there were an unusually high number of forest fires this year, would you expect any change in temperatures in the future? Explain your answer.

A large number of forest fires would produce large amounts of carbon dioxide that would go into the atmosphere and potentially increase the greenhouse effect, therefore increasing world temperatures. Some students might point out that this effect may be cancelled out because more smoke in the atmosphere would tend to block out more solar radiation.

Section 4: Follow-up Activities

Extra Help

1. Use the words from the following list to correctly fill in the blanks in the following paragraphs. Each word will be used once.

conservation	insulation	escape
transfer	absorbed	winter
non-renewable	RSI	improve
greenhouse	resists	radiation
heat		

When you know how to control heat ___*transfer*___, it is possible to make it happen more where you want it to and less where you do not. It is important for humans to ___*improve*___ their energy efficiency because the ___*non-renewable*___ resources such as oil and gas will run out one day. Trying to save these resources is called energy ___*conservation*___.

Material that stops heat from being transferred is called ___*insulation*___. Heat insulators can be compared using ___*RSI*___ values. This value tells us how much 1 cm of the material ___*resists*___ the transfer of heat.

The ___*greenhouse*___ effect happens because waves of light that get through the atmosphere easily are ___*absorbed*___ when they strike the earth's surface. This energy converts to ___*heat*___ and is re-emitted as infrared ___*radiation*___. Heat that is trapped in the atmosphere by carbon dioxide and water vapour cannot ___*escape*___ into space easily. This results in a warming effect that keeps the surface temperature relatively warm, even in ___*winter*___.

2. Fill in the following flow chart by providing correct information where some is missing.

Technological Problem Solving Steps

1. Understanding the Problem
- *know what must be achieved, purpose*
- *learn specifications, requirements*

2. *Develop a Plan*
- remember experiences
- research
- develop alternatives

3. Carry out the Plan
- *constuct the device*
- *troubleshooting*

4. *Evaluate the Plan*
- testing of the plan
- further troubleshooting

Enrichment

1. List the six main features of the R-2000 home.

   The six main features of the R-2000 home are the following:

   - *improved insulation and wall construction*
   - *reduced air leakage*
   - *ventilation and heat recovery systems*
   - *windows and doors that provide good insulation*
   - *direction of construction is towards the sun*
   - *appliances designed to consume little energy*

2. Many energy-efficiency improvements can be made to an existing home. Write a paragraph proposing some energy-saving improvements that could be made to your home. Assume that you have an unlimited budget, so cost is not a problem.

   Answers will vary widely. The student should suggest improvements similar to the features of the R-2000 home they have studied. Other suggestions intended to improve the energy efficiency of the house itself would be acceptable as well. For example, the student could explain that reinsulating the walls and including a vapour barrier would reduce conduction of heat by the walls. Also, improving the door seals and window caulking are other suggestions.

Section 4 Assignment

Read the notes along with the answers to the Section 4 activities for tips on how to help your student(s) complete this assignment.

Since the device that the student constructs cannot be submitted for marking, it is important that the student report fully on the process and the product by answering the assignment questions carefully.

Marking Guide:

Diagrams – award one mark for neatness and correct labelling and one mark for appropriateness. If an explanation is required, award one mark for each valid point required by the question up to the maximum allowed.

Short answer questions – award one mark for each point of information required by the question.

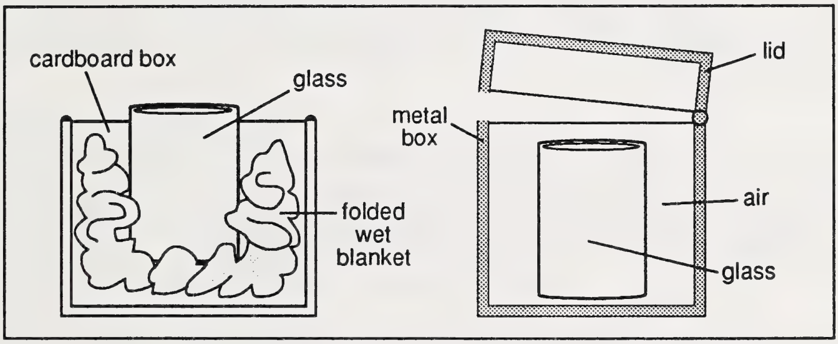
Fill in the blanks – award one mark for each correct answer to the maximum allowed. Spelling is important.

Mathematical questions – one mark for the answer and the remainder for steps required to arrive at the answer.

Suggested marks are shown in brackets.

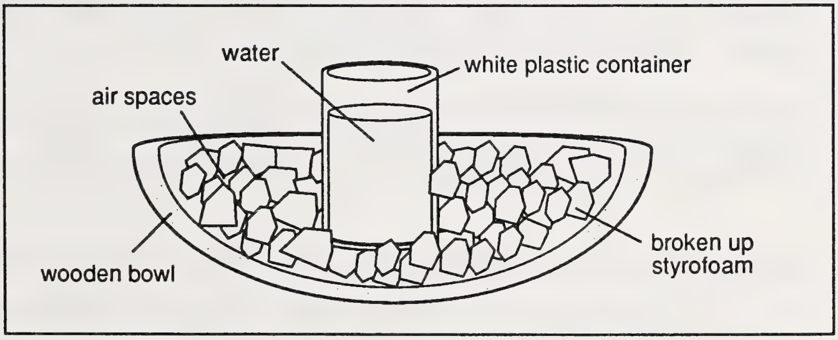
1. Draw and label sketches of two alternative designs that you did not choose for your device from Activity 2 of this section. (4 marks)

   Answers will vary. Sample answer:



2. a. Draw and label a sketch of the design that you chose for your device in Activity 2. (2 marks)

   Answers will vary. Sample answer:



   b. Give two reasons why you selected this design over the other alternatives. (2 marks)

   Answers will vary. Sample answer: The materials are less conductive than in the alternatives, and the styrofoam is easy to get from waste packaging.

3. Give an example of troubleshooting during the construction of your device. (1 mark)

   Answers will vary. Sample answer: I wanted to use 2 L of water but could not find a large enough plastic container, so I had to use less water.

4. Suggest two further refinements that could improve the way your device functions. (2 marks)

   Answers will vary. Sample answer: I would put a lid on it to prevent convection and bury the water container under styrofoam to prevent conduction through the top.

5. Describe a feature that your device has to limit heat transfer by conduction. (1 mark)

   Answers will vary. Sample answer: The plastic container is not very conductive so heat passed through it slowly.

6. Describe a feature that your device has to limit heat transfer by convection. (1 mark)

   Answers will vary. Sample answer: Because the styrofoam bits made little pockets of air outside the inner container, convection in the air was limited.

7. Describe a feature that your device has to limit heat transfer by radiation. (1 mark)

   Answers will vary. Sample answer: A white plastic container was used.

8. Explain the greenhouse effect by describing the energy of the sun which comes into the atmosphere, how it changes when it hits the earth's surface, and the reason it gets trapped near the earth. A diagram may be used to illustrate your answer. (3 marks)

   Light energy is a form of energy wave that can get through the atmosphere easily and strike the ground to be converted into heat. The heat waves emitted from the ground get trapped in the air by carbon dioxide, which reflects them back to the earth. A diagram could be used to show this.

9. Explain the effect that some human activities are having on the greenhouse effect. (2 marks)

   When people burn fuels (for transportation, industry, home heating, or electricity), the extra carbon dioxide in the air can increase the greenhouse effect.

10. Do question 9 on page 147 of the textbook. (3 marks)

    Conduction is minimized by the vacuum in the wall of the flask, the air space inside the plastic case, the glass walls of the flask, and the plastic walls of the case. Convection is minimized by a stopper which closes off the flask, a vacuum in the flask wall, and by a thin air space inside the case sealing the flask into the plastic case. Radiation is minimized by having a shiny inner surface and a shiny exterior. The response should include one point about each type of transfer.

11. What is the total RSI value for a triple-glazed window if the air spaces are 1.0 cm thick and the panes of glass are 0.3 cm thick? Show your calculations. (3 marks)

The total RSI value can be calculated by finding the separate RSI values for the air spaces and the panes of glass. (A triple-glazed window has three panes of glass and two air spaces.)

$$\begin{aligned} \textit{RSI for two airspaces} = 2 \times 1.0\ cm \times 0.15\ RSI/cm &= 0.30 \\ \textit{RSI for three panes of glass} = 3 \times 0.3\ cm \times 0.017\ RSI/cm &= \underline{0.0153} \\ \textit{Total RSI} &= 0.3153 \end{aligned}$$

Section 5: Heat Capacity

By heating up a variety of liquids, students will discover that different amounts of energy are needed to produce the same temperature change in different substances. This will be used to develop an understanding of specific heat capacity. Students will also learn that energy being transferred out of one object must end up being gained by surrounding objects.

> **Caution:** When using an electric heat source, students must be careful not to spill their liquids onto it. They are to use oven mitts or tongs to hold their hot beaker.

Section 5: Activity 1

The following materials are needed for this activity:

- safety glasses
- three different liquids including water, vegetable oil (or peanut, canola or olive oil) and glycerol (or corn syrup)
- three 250 mL Pyrex™ glass beakers (or one beaker which can be washed and dried for each new liquid)
- a heat source such as a hot plate or kitchen stove burner
- thermometer
- stirring rod
- timing device (in minutes and seconds)
- balance (or a 100 mL graduated cylinder)
- tongs or gloves

1. What is the problem for this investigation?

   Students should indicate that there may be a difference in the amount of heat required to produce the same temperature increase in different liquids.

2. Do step 3 of the procedure. If a balance is not available, you may determine the number of mL of liquid required to obtain a 100 g mass by using the following table. Use a graduated cylinder to measure the volume required for 100 g of mass. Repeat step 3 for all three liquids.

Substance	Density (g/mL)	Volume Required for 100 g mass (mL)
glycerol (or corn syrup)	1.26	79
water	1.00	100
vegetable oil (or similar oil)	0.92	109

   Care is required when measuring amounts of liquids to be heated.

3. Which of the liquids do you predict will heat up the fastest?

   Answers may vary. Students may choose the ones with the smallest volumes, based on previous experience with a single liquid such as water.

4. The following table will be used to record data for this demonstration. Record the names of the three liquids that you plan to use in the spaces at the top of the table.

   Answers will vary, but should include three of the liquids mentioned in question 2. Sample data is given in the chart on the opposite page.

Heading Liquids

Time (minutes)	Temperature of *Water* (°C)	Temperature of *Vegetable Oil* (°C)	Temperature of *Corn Syrup* (°C)
0.0	30	30	30
0.5	*33*	*35*	*30*
1.0	*36*	*40*	*34*
1.5	*40*	*45*	*38*
2.0	*42*	*50*	*42*
2.5	*45*	*55*	*46*
3.0	*48*	*60*	*50*
3.5	*51*	*65*	*55*
4.0	*55*	*70*	*59*
4.5	*58*		*63*
5.0	*62*		*67*
5.5	*65*		*70*
6.0	*68*		
6.5	*72*		
7.0			

5. Do steps 4 and 5 of the procedure. Record your data in the table provided. You will record the temperatures of the three liquids every 30 seconds. For each liquid, timing will begin when the temperature reaches 30°C and stop when the temperature reaches 70°C.

   See the previous table for sample data.

Comment: For questions 6 and 7, the textbook questions are from page 151.

6. Do questions 1 and 2 of Analysis.

   Textbook question 1:

   Water is the best answer, but any answer is acceptable if it is consistent with the data.

   Textbook question 2:

   The answer should be consistent with the data collected, but the order should show that vegetable oil heated fastest, then glycerol, and then water.

7. Do questions 3 and 4 of Further Analysis.

   Textbook question 3:

   Whichever liquid took the longest to warm up absorbed the most heat energy. The answer should be consistent with the data that was collected, but the correct answer is water.

   Textbook question 4:

   Answer should be consistent with data collected, but the correct order from greatest to least heat capacity should be water, glycerol, and vegetable oil.

8. What is one application of water's high heat capacity that is given in the textbook?

   Water is a good coolant for machinery.

Section 5: Activity 2

1. In the metric system, heat is measured in units called ___*joules*___. The symbol for this unit is ___*J*___. The amount of energy that it takes to change the temperature of 1 kg of a substance by 1°C is called its ___*specific heat*___ ___*capacity*___.

2. The unit of specific heat capacity, stated using symbols, is *J/(kg°C)*. The specific heat capacity of water is *4200* J/kg°C. This means that it takes *4200* J of heat to cause a temperature change of *1* °C in 1 kg of water.

3. A 1 kg sample of water received 8400 J of heat and its temperature rose by 2°C. If another 16 800 J of heat are transferred into it, the temperature will go up by *4* °C.

4. If a 1 kg sample of ethanol (check table 3-3 on page 153) receives 5000 J of heat, its temperature will go up *2* °C. If given the same amount of heat, a sample of ethanol half as big (500 g) would experience a rise in temperature of *4* °C.

5. When put into the refrigerator, a 1 kg sample of vegetable oil lost 10 000 J of heat, so the temperature would have gone down by *5* °C. To have the temperature go down by 20°C, *40 000* J of heat must be lost. If this amount of heat was transferred out of a 2 kg sample of vegetable oil, the temperature would go down by *10* °C.

6. If 920 J of heat were added to a sample of aluminum to increase its temperature by 1°C, *2760* J of heat would need to be added to raise its temperature by 3°C.

7. To lower the temperature of a 10 kg block of brass by 10°C, you would have to remove *38 000* J of heat.

8. 5 kg of ethanol and 5 kg of ethylene glycol both had their temperatures raised by 1°C. Which substance would have required more joules of heat?

   Ethanol required more joules of heat because it has the higher specific heat capacity of the two.

Section 5: Activity 3

1. What is the scientific law that states "Energy is never created or destroyed"?

   The fact that energy is never created or destroyed is referred to as the Law of Conservation of Energy.

2. When you try to adjust the water temperature at a faucet, where else does the heat from the hot water end up, besides in the cold water?

   The heat can go into the pipes, the air, and any fixtures such as taps.

3. If 100 mL of water at 80°C are mixed with 100 mL of water at 40°C, the final temperature of the mixture should be ____*60*____ °C.

4. If 200 mL of water at 80°C are mixed with 100 mL of water at 50°C, the final temperature of the mixture should be ____*70*____ °C.

5. If 100 mL of water at 80°C are mixed with 200 mL of water at 50°C, the final temperature of the mixture should be ____*60*____ °C.

Section 5: Follow-up Activities

Extra Help

Solve the following puzzle by using the words in the word list to answer each clue. Place the words in the spaces, letter by letter, to reveal something that is very important to think about when you are talking about heat!

Word List

gain	vegetable	equation
joule	iron	heat capacity
hydrogen	energy	temperature
heat	specific	transfer

1		H	E	A	T	C	A	P	A	C	I	T	Y	
2		H	Y	D	R	O	G	E	N					
3					E	N	E	R	G	Y				
4						S	P	E	C	I	F	I	C	
5					H	E	A	T						
6	T	E	M	P	E	R	A	T	U	R	E			
7						V	E	G	E	T	A	B	L	E
8				T	R	A	N	S	F	E	R			
9		E	Q	U	A	T	I	O	N					
10				G	A	I	N							
11					J	O	U	L	E					
12			I	R	O	N								

Solution: An important thing to think about when you are talking about heat is *conservation*.

Enrichment

Students may do either Part A or Part B, or both.

The following materials are needed for this activity:

Part A

- calculator

Part B

- two beakers or plastic cups
- two thermometers
- stirring rod
- graduated cylinder or measuring cup
- large container for mixing water samples
- hot and cold water

1. Do questions 1, 2, and 3 in Activity 3-10 on page 156 of the textbook. Show your work.

   Textbook question 1:

$$\textit{mass of mercury} = 2.5\ kg$$
$$E = 3200\ J$$
$$\Delta t = 32 - 22 = 10°C$$
$$\textit{formula:}\ \ c = \frac{E}{m\Delta t} = \frac{3200\ J}{2.5\ kg \times 10°C}$$
$$\textit{answer} = 128\ J/(kg{\cdot}°C)$$

   Statement: The specific heat capacity of mercury is $128\ J/(kg°C)$.

   Textbook question 2:

$$E = 1.3\ kJ = 1300\ J$$
$$m = 400\ g = 0.4\ kg$$
$$\Delta t = 75 - 50 = 25°C$$
$$\textit{formula:}\ \ c = \frac{E}{m\Delta t} = \frac{1300\ J}{0.4\ kg \times 25°C}$$
$$\textit{answer} = 130\ J/(kg{\cdot}°C)$$

   Statement: The specific heat capacity of gold is 130 J/(kg °C).

Textbook question 3. (a):

To find E, you must first find the energy transferred to the water.

$$m = 200\ g = 0.2\ kg$$
$$\Delta t = 35 - 15 = 20^\circ C$$
$$C = 4200\ J/(kg\cdot{}^\circ C)$$

formula: $E = m\Delta tc$
$$= 0.2\ kg \times 20^\circ C \times 4200\ J/(kg\cdot{}^\circ C)$$
answer $= 16\ 800\ J$

Now, the specific heat of the metal can be found.

$$E = 16\ 800\ J$$
$$m = 400\ g = 0.4\ kg$$
$$\Delta t = 85 - 35 = 50^\circ C$$

formula: $c = \dfrac{E}{m\Delta t} = \dfrac{16\ 800\ J}{0.4\ kg \times 50^\circ C}$

answer $= 840\ J/(kg\cdot{}^\circ C)$

Statement: The specific heat of this unknown substance is 840 J/(kg°C).

Textbook question 3. (b):

The substance is probably glass.

2. Determine the capacity of your mixing container by filling it almost to the top with water and then pouring the water out into the graduated cylinder. Each time that you fill the graduated cylinder record the total. Do this until your container is empty. The total capacity of the mixing container is ________________ mL. The amounts of hot and cold water you mix cannot add up to more than this limit.

   Answers will vary, depending on the container used.

3. For each of the five mixtures you will be making, determine beforehand how much cold and hot water you will use and enter the amounts into the following chart. Storing the water in a poorly conductive container will prevent some heat transfer, but you should work fairly quickly to determine the temperatures of the two samples, record them in the chart, and mix the samples together using the stirring rod. Take a moment to record a prediction of the final temperature before measuring and recording the actual final temperature. Repeat this procedure five times, each time selecting different proportions of hot and cold water.

Sample Results:

Mixing Hot and Cold

Cold Water		Hot Water		Mixture Temp.	
Amount (mL)	Temp. (°C)	Amount (mL)	Temp. (°C)	Prediction (°C)	Actual (°C)
50	*22*	*50*	*60*	*41*	*38*
100	*22*	*50*	*60*	*35*	*32*
50	*22*	*100*	*60*	*47*	*44*
75	*10*	*75*	*80*	*45*	*40*
5	*10*	*140*	*80*	*78*	*75*

4. Make a statement about how close your predictions were to the actual final temperatures. Were your predictions usually low or high?

The predictions were within 5°C of the actual final temperatures and were always higher than the actual. Student answers should be consistent with the data collected.

5. Does it appear that all of the heat lost by the hot water is gained by the cold water?

It seems like some of the heat goes elsewhere because the final temperature is always low. Student answers should be consistent with the data collected.

6. Where else could the heat be transferred to, besides the cold water?

The heat could be going into the containers, the air, the stirring stick, and the thermometer.

Section 5 Assignment

Marking Guide:
Short answer questions – award one mark for each point of information required by the question.

Fill in the blanks – award one mark for each correct answer to the maximum allowed. Spelling is important.

Suggested values are shown in brackets.

1. Explain why cities near large bodies of water are warmer during the winter than cities that are not near large bodies of water. (3 marks)

   The temperature in cities near large bodies of water are warmer because water has a high heat capacity. This keeps the air warmer because the water hangs on to heat for a long time.

2. Why is it difficult to prove the Law of Conservation of Energy in a science classroom? (2 marks)

   Heat gets transferred into places other than where intended (for example, into the container, the air, the thermometer, and the stirring rod). This results in errors in the data which usually cause the results to show more heat loss than heat gain.

3. If a substance has a high heat capacity, what is true about the amount of energy needed to raise its temperature? (1 mark)

   A large amount of heat energy would be needed to raise its temperature.

4. Use Table 3-3 on page 153 of your textbook to help you fill in the blanks. (4 marks)

   From Table 3-3 on page 153, the most difficult liquid to warm up is ___*water*___ with a specific heat capacity of ___*4200*___ J/(kg C). The easiest solid to warm up would be ___*lead*___ with a specific heat capacity of ___*130*___ J/(kg C).

5. Use your knowledge of heat capacity to help you fill in the blanks. (2 marks)

   To raise the temperature of 100 kg of concrete by 1°C would require ___*300 000*___ J of heat. If transferred to 100 kg of iron would the same amount of heat produce a greater or lesser change in temperature? ___*greater*___

6. Explain what specific heat capacity means. (3 marks)

   Specific heat capacity is the amount of heat energy needed to raise the temperature of 1 kg of a substance by 1°C.

7. State the Principle of Heat Transfer in mathematical terms and then use hot and cold water to explain what it means. (3 marks)

   heat released = heat gained
   When heat energy is transferred out of hot water, the same amount of heat is taken into the cold water.

8. Use your knowledge of conservation of heat to help you fill in the blanks. (2 marks)

   If mixed in a perfectly insulated container, 100 g of water at 60°C together with 100 g of water at 20°C should end up being ____*40*____ C. Would being mixed in a poorly insulated container such as a tin can cause the final temperature to end up being higher or lower?

   ____*lower*____

Section 6: Solar Heating

In this section the student will learn about passive and active solar heating systems. This information, along with the material covered during the entire module, will be put to use in the design and construction of a model solar home.

Section 6: Activity 1

1. What is the difference between renewable and non-renewable energy resources?

   Non-renewable resources are in limited supply, whereas the supply of renewable sources is self-replenishing. Non-renewable resources will run out, but there will always be renewable resources.

2. Name five renewable energy resources.

   Food, water power, wind, wood, and energy from the sun are all renewable resources.

3. What four topics that you have already studied in this module are involved in solar heating technology?

   Conduction, convection, radiation, and heat capacity are all involved in solar heating.

4. Describe what *passive* means in reference to solar heating.

   A passive system simply lets solar energy in and prevents heat from transferring out.

5. What are two reasons that passive solar heating is popular?

   Passive solar heating is not expensive and it is easily maintained.

6. Describe three design features that windows can have to assist passive solar heating.

   The student should mention at least three of the following: large south-facing windows, small north-facing windows, wide overhangs on south side, shutters, double or triple glazing, and being well weather-sealed.

7. Explain how deciduous trees on the south side of the house can help keep the house warm in winter and cool in summer.

   In the summer, the leaves on the trees help shade the house. In winter there are no leaves and the sun can shine onto the house to help warm it.

8. Why would evergreen trees be placed on the north side of the house?

   Evergreens never lose their leaves and offer continuous protection against the wind, especially the cold north wind.

9. How can your choice of construction material affect how warm you will be in the house at night?

   Using a material with a high specific heat capacity means that although it takes a long time to warm up, it will also take a long time to cool and will release its heat during the night.

10. Explain how termite mounds take advantage of passive solar heating.

Termites build their mounds so that the morning sun strikes the broad side of the mound to help warm up the cold-blooded insects. During the heat of the day, the sun strikes the narrow side of the mound so that it does not overheat.

Section 6: Activity 2

1. What is the basic difference between passive and active solar heating systems?

Active systems absorb and distribute the energy by carrying it to another part of the house.

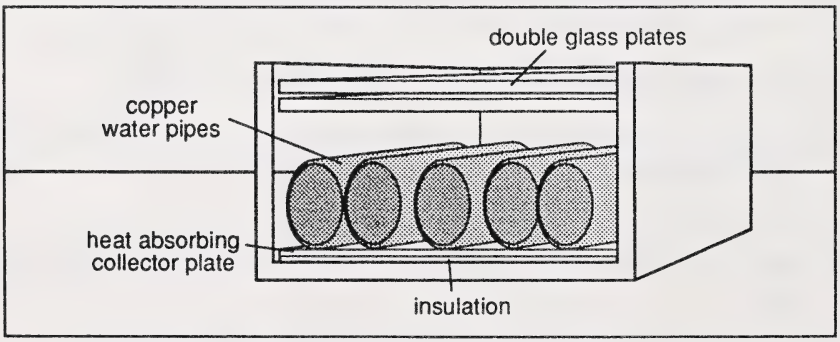
2. What type of material is usually used to absorb and distribute heat in an active system? Why is this a good choice?

Liquids (usually water) are used to absorb and distribute the heat in an active system. This is a good choice because liquids flow easily but do not expand very much when heated.

3. Why is it important to aim solar collectors towards the south?

In order to catch the sun's rays, the collector must face the sun, which is found in the southern sky most of the time.

4. Copy the diagram of a flat solar collector found at the bottom of page 159 in your textbook.



5. What is the function of the double glass plates on top of the flat collector?

They allow light to pass in but trap the heat. The dead air space helps stop the heat from escaping by conduction.

6. What makes copper a good choice of material for the water pipes?

   Copper has a high thermal conductivity rating. It will absorb heat quickly.

7. What is the purpose of the insulation under the water pipes?

   The insulation helps prevent loss of heat through the bottom of the collector.

8. What two things make the liquid circulate in an active collector system?

   Convection and electric pumps circulate the liquid in an active system.

9. Explain the use of curved solar collectors like the one in the photograph on page 160 of your textbook.

   These collectors focus the radiation on one spot.

10. What does an automatic tracking system do for a solar collector?

    An automatic tracking system keeps the collector facing the sun.

11. Explain one advantage and one disadvantage of using antifreeze in active solar heating systems.

    Antifreeze keeps the liquid in the collector from freezing, but lowers the specific heat capacity of the liquid.

Section 6: Activity 3

The following list of materials is suggested for this activity:

- aluminum foil
- wire
- plywood
- straws
- tin cans
- cardboard (boxes)
- plastic
- popsicle sticks
- string
- wallpaper scraps
- coloured paper
- plastic wrap
- poster paint
- tape
- white hobby glue
- insulating materials (polystyrene, fibreglass, and various types of cloth)

A wide variety of materials may be used for building the model solar home. The total amount of material depends on the size of the model that the student wishes to make.

The following list of resources is suggested for this activity.

- Referencing materials as a source of information and ideas pertaining to solar energy and solar homes are recommended.

- Free materials, including a booklet called "Passive Solar" and a pamphlet called "Active Solar" are available from:

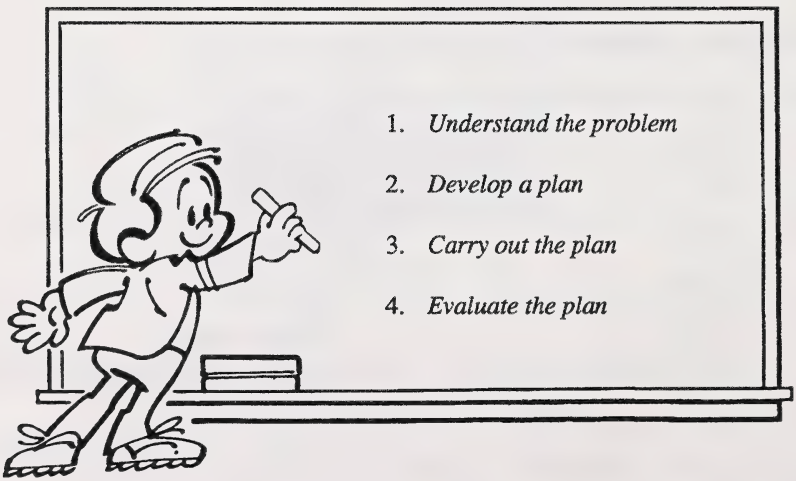
  Alberta Government
  Department of Energy Conservation
  7th floor, North Petroleum Tower,
  9945 – 108 st.
  Edmonton, Alberta
  T5K 2G6
  phone: (403) 427 – 6902

To obtain the maximum benefit from the activity, students should be encouraged to seek out a variety of ideas in library books, magazines, and the government publications previously mentioned.

The answers to questions 1 to 7 in this activity should be checked before the student proceeds to construct the model solar home. They should have included details in all areas referred to in the activity.

If working in a class setting where several students or groups of students are building models, it is important to share the final products, especially those with unique or unusual features. This will help the students appreciate that problems can be solved in a variety of correct ways.

1. Fill in the steps that you will take by following the technological problem-solving model.



2. From the information given so far in this investigation, what is the problem for this investigation?

   The proble is to design and construct a model solar home using passive and active solar heating. The student may state this in other ways.

3. What passive solar features will you include in your solar home?

   The student may mention such features as having large windows on the south side of the house and small windows on the north side, using rock material to absorb and store heat, window shutters, evergreen trees on the north side, deciduous trees on the south side, wide overhangs above the south windows, and R-2000 features such as insulation, vapour barriers, and extensive weather sealing.

4. What active solar features will you include in your solar home?

   The student may describe a system in which a collector on the south side of the house absorbs radiant energy into a liquid, usually water, which carries the heat to a storage and distribution system in the house.

5. What interior floor plan considerations will you include to use the position of the sun to your advantage?

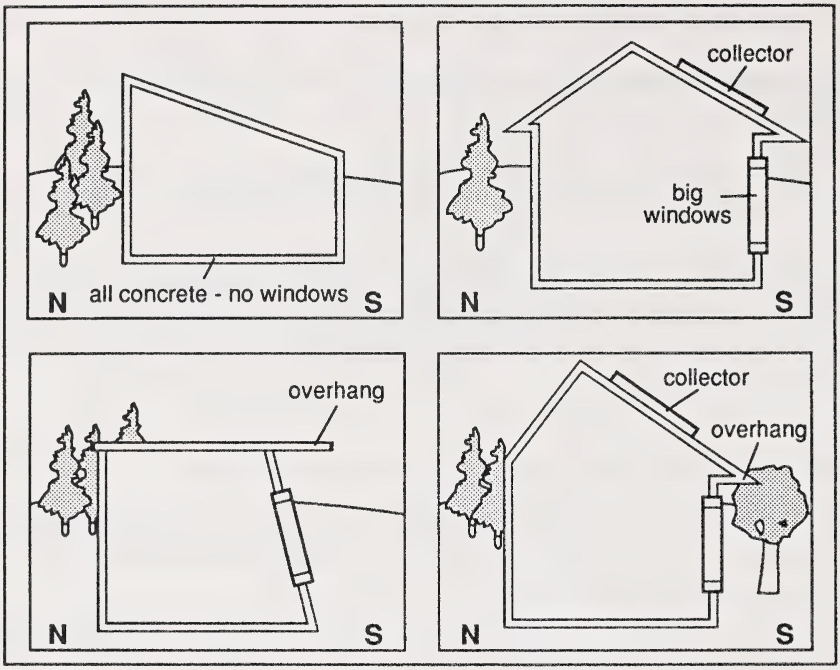
   The student may describe that a certain room in the house be located to receive sunlight and shade at certain times of the day. For example, the bedroom might be placed on the east side so that it will not get any sun late in the day, keeping it cool, but so that it will receive the morning sun.

6. What landscaping considerations will you include to use the positioning of vegetation to your advantage?

   Evergreen trees on the north side protect the house from wind. Deciduous trees on the south side keep the house shaded in summer, but allow the rays of the sun to strike it in the winter.

7. Make three or four drawings of home designs that you could build. Afterwards, highlight the one that you think is best.

   Examples are shown on the following page.



When examining student plans, be sure to check for reasonable expectations of size and materials. They should include elements of active and passive solar heating.

8. What changes did you make to your plan while making your model home? Give one example of troubleshooting during construction.

   Answers will vary. The student may have made a switch in materials, such as deciding to build brick walls instead of stone, or a design change such as altering the placement of a collector.

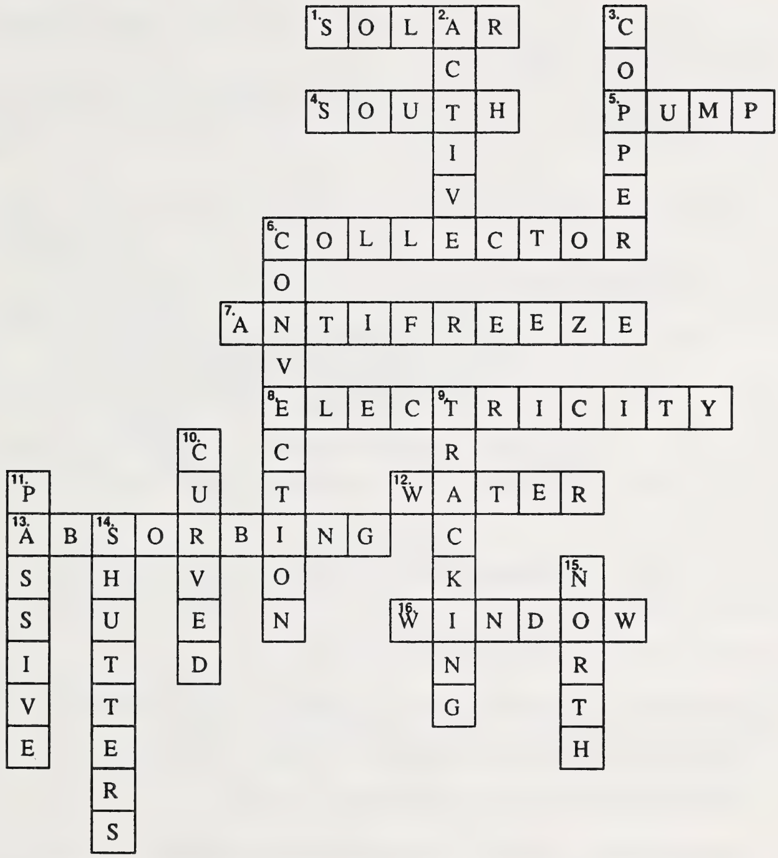
Section 6: Follow-up Activities

Extra Help

Select words from the following list to correctly complete the crossword puzzle.

Word List

passive	copper	south	shutters
active	water	north	electricity
window	antifreeze	tracking	convection
collector	pump	solar	curved
absorbing			



Enrichment

Students may do either Part A or Part B, or both.

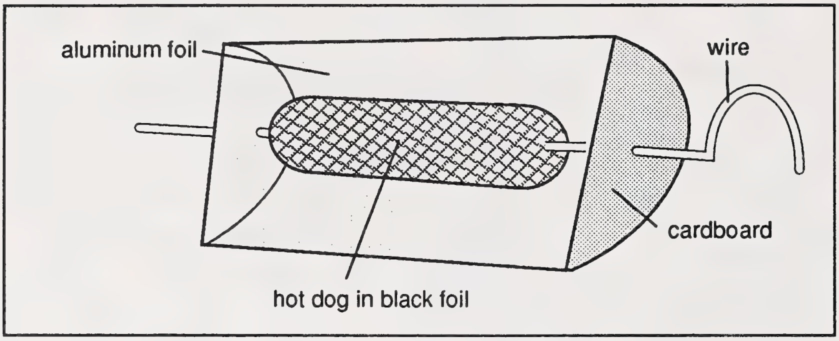
The following materials are suggested for this activity. Individual projects will determine the materials required.

- cardboard
- hobby knife
- white hobby glue
- tape
- aluminum foil or other reflective material
- paints
- wire coat hangers
- wire cutters
- hot dogs or marshmallows
- any other materials that you or the student might prefer to use.

1. Draw and label a sketch of your solar cooker. Build your cooker according to this design with materials that are available to you.

   Answers may vary.

   Example:



2. Explain how your cooker is expected to function.

   Answers will vary. Example: The rays of the sun will be reflected onto the hot dog and be absorbed by the black foil so that heat will cook the hot dog.

3. After testing the cooker, report on how well it worked.

   Answers will vary. Example: The cooker got quite hot but it still took the hot dog 15 minutes to cook. The cooker had to be moved around to keep it in focus.

4. What aspects of your design would you try to improve if you were to build another cooker?

   Answers will vary. Example: I would make the reflective surface bigger to catch more rays.

5. Write a paragraph telling about what it is that Alan finds exciting about his studies and his career. What non-scientific things does Alan do in his job? What do meteorologists actually do?

   Answers will vary widely, but students should mention such details as Alan's excitement about the physics of atmospheric science and the way that he thinks of it as an "incredible puzzle". Several aspects of Alan's job may appeal to students, for example, he supplies weather forecasts to television stations and develops exhibits for the public. Meteorologists produce weather forecasts and may study hurricanes or tornadoes, build computer models of the atmosphere, monitor acid rain, or study climate changes.

Section 6 Assignment

In order to compete this assignment, your student must also have completed Activity 3 of this section. If actual construction of a model is not possible in your situation, the minimum requirement is a detailed design.

Read the notes included with answers to Section 6: Activity 3 for tips on how to help your student do well on this assignment.

Since it is not possible to submit model homes for marking, it is important that the student report fully on the construction process and complete all of the assignment questions carefully.

Marking Guide:

Diagrams – award one mark for neatness and one mark for appropriateness. If an explanation is required, award one mark for each valid point or label required by the question up to the maximum allowed.

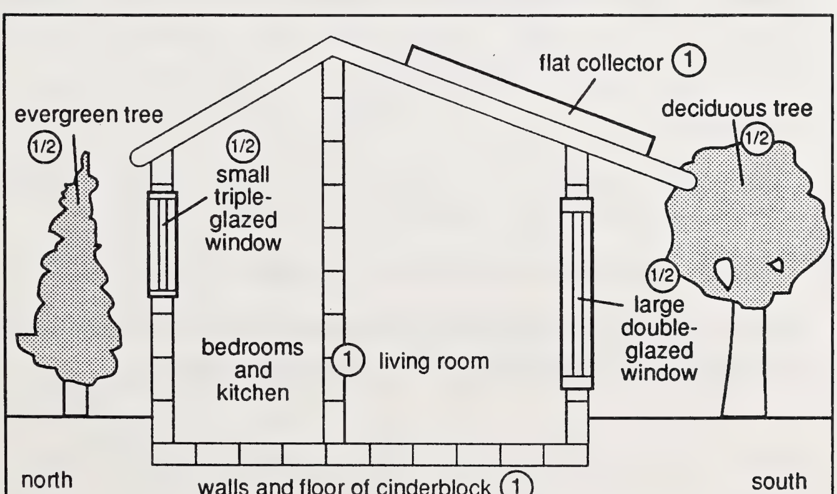
Short answer questions – award one mark for each point of information required by the question, or award the suggested value given in brackets if the answer includes all the information asked for by the question.

Suggested marks are shown in brackets.

1. Draw and label a sketch of the design that you chose for your solar home model. (7 marks)

   Answers will vary, but good detail should be present.

   Example:



2. Give an example of troubleshooting during the construction of your model solar home. *(4 marks)*

   The student should mention some decision made during the process of construction. For example, after discovering that the straws used for the flat collector melted with one type of glue, another type of glue was found, or some design change, such as a change in the placement of a solar collector, may have been made.

3. Imagine that you are a home builder and would like to be able to promote your design as an energy efficient home. The following questions will help you evaluate your design. In each case you must first answer **yes** or **no**. (14 marks)

   - If you answer **no** to a question, tell how this will effect the energy efficiency of the home.

   - If you answer **yes** to a question, tell how this will improve the energy efficiency of the home.

   Answers can be yes or no, but should be justified in terms of how they would affect energy efficiency. If the answer is yes, the following answers may be expected. If the answer is no, the negative should be stated.

   a. Are the walls and floors of the home well insulated? If so, what material is used?

      A well-insulated home will prevent loss of heat due to convection and conduction. Insulating materials include fibreglass insulation for between walls, rigid polystrene on the exterior side of the walls, and foam underlay for under rugs on the floors.

   b. Are reflective surfaces used in the home? If so, where and why?

      Reflective surfaces could be used as backing for insulation to prevent loss of heat due to radiation from the structure. Reflective surfaces can also be used to collect energy or to direct sunlight towards solar collectors.

   c. Are there small windows, or no windows at all, on the north side of the home?

      Small windows on the north side will create less heat loss due to conduction through them. This provides relatively poor insulation when compared with the walls.

   d. Are there large windows on the south side of the home?

      Large south-facing windows will allow more solar energy to enter the home where it is converted to heat. This can be a valuable energy saver in winter.

e. Are there movable shutters on the windows?

Movable shutters on the windows will prevent overheating due to sunlight entering the house in summer.

f. Are the windows triple-glazed (three panes of glass)?

Triple-glazed windows have higher R-factor than double or single-glazed windows. They allow less heat loss due to conduction. Special coatings on the glass can also reduce loss of heat due to radiation.

g. Do you have evergreen trees on the north side of the home?

Evergreens on the north side of a house can act as a wind break. Windy conditions will cool the outer walls more rapidly than calm conditions.

h. Are there deciduous (leaf-bearing) trees on the south side of the home?

Deciduous trees provide shade in summer and allow sunlight to enter windows and warm walls in winter.

i. Is there a hill or berm on the north side of the home?

A berm or hill on the north side of the home will act as a windbreak. It will also warm up due to sunlight striking it during the day. This heat will be stored in the ground and radiated toward the home during the night.

j. Do all solar collectors face south?

Solar collectors should face south to obtain maximum exposure to sunlight.

k. Do the solar collectors contain an antifreeze solution with high heat capacity?

Antifreeze with high heat capacity in solar collectors enables heat to be stored in reservoirs and transferred quickly to where it is needed, even in cold weather.

l. Is there a heat storage site as part of the active system in the home?

Active solar heating requires a large storage site for heat that can be used later.

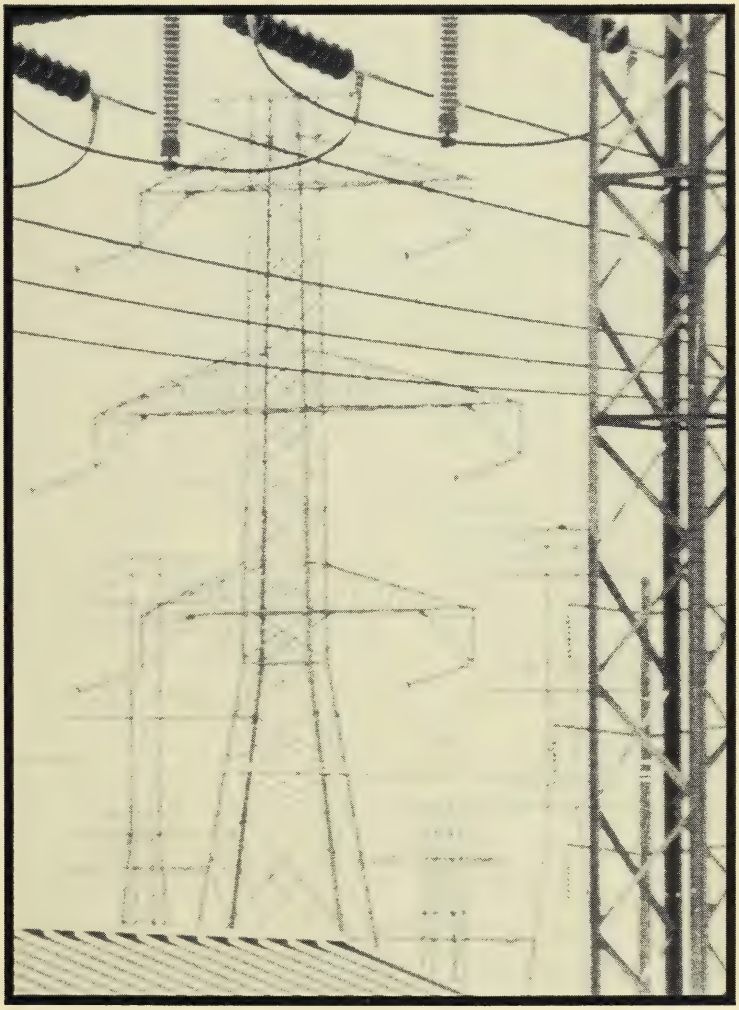
m. Have you placed a particular room in a position to get lots of sun? If so, which room?

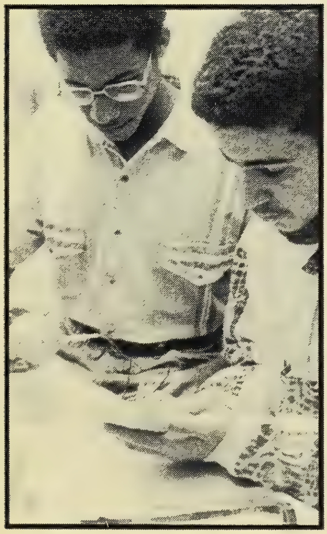
Living areas, atriums or kitchens would all benefit from more light and heat.

n. Have you placed a particular room in a particular position to get little sun? If so, which room?

Bedrooms are normally placed on the north side where it is darker and cooler.

SCIENCE 9





Module 4

Electromagnetic Systems

LEARNING FACILITATOR'S MANUAL

Distance Learning

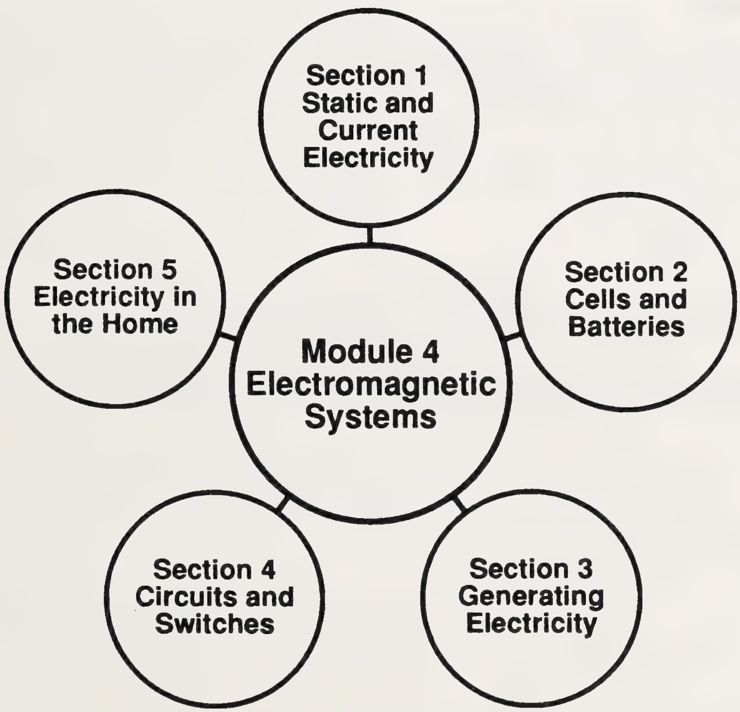
Alberta EDUCATION

Module 4 – Electricity: Overview

The major emphasis of this unit is science and technology.

In this module students will look at the principles of electricity. They will explore the basis for production, control, and use of electrical energy. Students will be asked to solve some practical problems using basic electrical circuitry.

There is a connection between the study of electrochemical cells and chemical properties and changes. Another important connection is between the control of electricity and the control of fluids and pressure.



Classroom Opener

Begin by showing the class a flashlight that does not work. This should be prepared beforehand. Ask the class why the flashlight does not work. Have the students give suggestions as to how they might solve the problem.

The following questions and topics may be discussed: Why might the bulb or batteries fail to work? Does a new bulb and new batteries fix the problem? How does electricity get from the batteries to the bulb? Could there be a problem in the electrical pathway? What do we call this pathway?

Announce that this module is about the technology that allows us to use electricity. At the end of this module, students will be able to troubleshoot a variety of electrical problems.

Media

Videocassettes may be available from your regional media centre. If not, contact the ACCESS Network for more information.

The following videos are included in this module:

- *Electricity*
- *Volton*

Materials and Equipment

The required materials and equipment are listed under each activity. In planning for the acquisition of the required materials and equipment, you may find it useful to preview these lists.

Some lists will have sublists for Part A and Part B. This reflects pathways in the Student Module Booklet. Materials and equipment will be needed for either Part A or Part B, but not both.

Evaluation

The mark in this module will be determined by students' work in the Assignment Booklet. Students must complete all assignments. In this module students are expected to complete four section assignments and a final module assignment.

The assignment breakdown is as follows:

Section 2 Assignment	**15%**
Section 3 Assignment	**20%**
Section 4 Assignment	**25%**
Section 5 Assignment	**10%**
Final Module Assignment	**30%**
TOTAL	**100%**

Section 1: Static and Current Electricity

In this section students will learn that electricity can exert either a pushing or pulling force. They will learn that wires carry electricity and that electricity moves from one place to another. They will also begin to see evidence of electromagnetic forces and build a simple galvanometer.

This is an introductory section. Most students should have a preconceived idea about what electricity is. This section will ensure that their ideas are clear and correct.

Section 1: Activity 1

The following materials are needed for this activity:

- one piece of puffed wheat or a similarly sized piece of polystyrene foam
- 20 cm of thread
- a strip of vinyl plastic (This can be cut from an ice-cream pail lid.)
- a piece of wool or fur
- a polystyrene foam cup
- a 10 cm common nail
- a glass rod
- a 10 cm wooden dowel

This could be a frustrating investigation under certain circumstances. Weather conditions, such as high humidity, may make it difficult to produce a charge. Students should be patient and try a variety of materials in different combinations. For example, they may try a plastic comb, or a thin plastic ruler as their strip of vinyl plastic. If other substitute materials are necessary, students may use a popsicle stick instead of a 10 cm dowel, or a glass instead of a polystyrene cup.

Students may have difficulty understanding that there are two different types of charges. However, they should at least be aware that pushing and pulling forces exist between electrical charges and between electrical charges and neutral objects. These forces produce a movement of electrons, or electricity. Substances that allow the movement of electrons through them are called conductors.

1. Define the following terms.

   a. static electricity: *a build-up of electrical charges on an object*

   b. electrical force: *attracting or repelling force between objects or particles that have an electrical charge*

2. What do you observe when you bring the plastic strip (and an electric charge) close to the piece of puffed wheat?

   The puffed wheat is attracted to the charged strip.

3. How has the response of the puffed wheat changed?

   The puffed wheat is now repelled by the plastic strip.

4. What type of force occurs between like charges?

   There is a repelling force between like charges.

5. How does the piece of puffed wheat respond to the charge on the wool?

   There is a strong attractive force.

6. How is this response different from the one observed in question 4?

   Students should have seen an attractive force between the wool and the puffed wheat and a repelling force between the plastic strip and the puffed wheat.

7. Is the charge on the wool the same as the charge on the plastic strip? How do you know?

   The charge on the strip is different because there is an attractive force, rather than a repelling force.

8. What evidence is there for the existence of forces between electrical charges?

   You can see attracting and repelling forces between electrically charged objects.

9. Use your observations to determine whether attracting or repelling forces would be observed between the following charges.

	Type of Force
a. a charged object and an uncharged object	*attracting*
b. two like charges	*repelling*
c. two unlike charges	*attracting*

10. Why were you asked to touch the piece of puffed wheat at the end of the procedure?

    Touching the puffed wheat removed the electrical charges and made the puffed wheat neutral.

11. Name the two electrical charges observed in your investigation.

    Positive and negative charges were observed.

12. What charged particle is responsible for the movement of negative charges?

    The electron is responsible for the movement of negative charges.

13. State the three laws of electrical charges.

    - *Opposite charges attract.*
    - *Like charges repel.*
    - *Charged objects attract neutral objects.*

14. What observations tell you that an electrical charge can travel through some substances and not others?

    Students should observe the presence of an attractive force at the end of the nail, but not at the end of the glass rod or wooden dowel.

15. Which substance(s) are conductors of electricity?

    The iron nail is a conductor. Metals are the usual conductors of electricity.

16. Which substance(s) are non-conductors of electricity?

    Glass and wood and other non-metals, such as plastics, are non-conductors. Students may wonder how the plastic strip can hold a charge yet not be a conductor. This is because the charge is due to an accumulation of electrons on the surface. It is not a transmission of electrons through the material.

Section 1: Activity 2

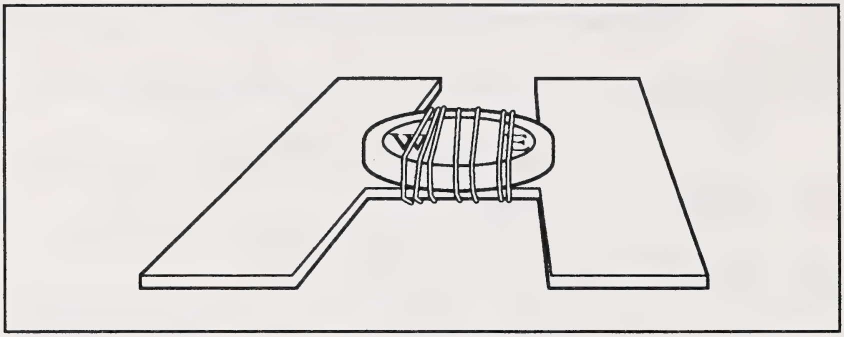
The following materials are needed for this activity:

- compass
- 2 m of insulated 26 gauge copper wire
- two alligator clip connectors
- emery cloth or fine sandpaper
- black electrical tape
- one D-sized cell in a holder (Students may make this using instructions in their booklet.)
- 3 V bulb and socket

As the students are doing this activity, make sure they have their compasses pointed north. Also make sure their compasses are not near any metal objects. Although 26 gauge copper wire is suggested, other thin insulated wire such as 24 gauge or 28 gauge wire can be substituted. Ensure that the students record their data accurately.

To ensure the life of the battery, have students hold the wires to the battery for a short period of time.

As the number of loops increases, they may tend to fall off. Have the students tape them in place. There are a variety of ways to make a permanent mount for the compasses. The bottom of a polystyrene cup may be used or the students can create a H-shaped cardboard or wooden frame and wrap the wire around the compass between the two uprights of the "H".



It would be useful to have a galvanometer to show the students.

1. What is meant when you talk about current electricity?

   Current electricity is the movement of charged particles from one point to another through a conductor.

2. What two things do you need in order to make electricity move from one point to another?

   In order to make electricity, you need the following two things:

   - *a source of charged particles*
   - *a pathway or conductor to carry charged particles between points*

3. Current electricity can be very dangerous. What is one thing you should never do around the house?

   You should never experiment with appliances and other electrical devices around the house.

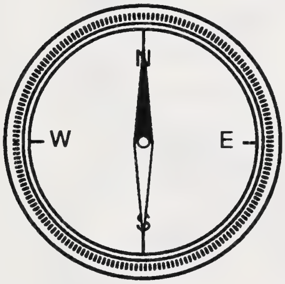
4. What is the problem for this investigation?

   The problem may be stated as follows: How can you make a device to detect and compare electrical current?

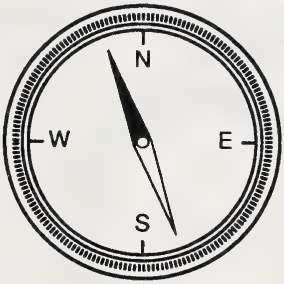
Comment:

For questions 5 to 13, students' answers may be opposite to the ones shown here, but their answers are still correct. Students may have connected the wires to the opposite terminals of the cell. This will reverse the direction in which the compass needle points. Students should show the dark and light ends of the compass needle in their drawings.

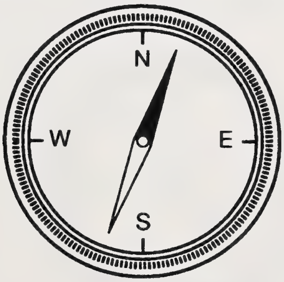
5. Complete the following sketch by showing the position of the compass needle before connecting the cell in step 3.



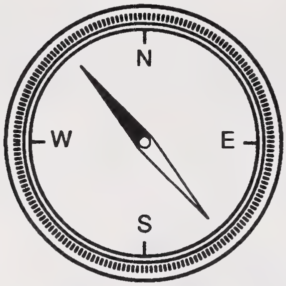
6. Complete the following sketch to show the position of the compass needle after briefly connecting wires to the cell.



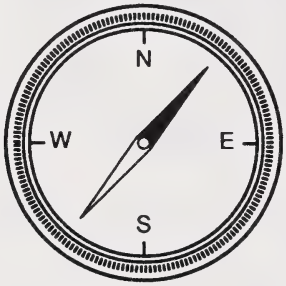
7. After reversing the connection, complete the following sketch to show the new position of the compass needle.



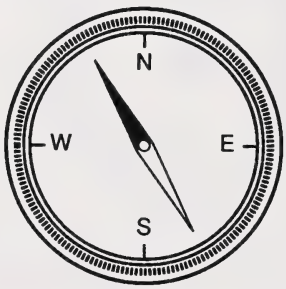
8. Indicate the position of the needle when the wire is below the compass and briefly connected to the cell.



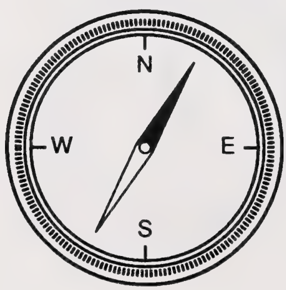
9. Indicate the position of the needle after reversing the connection.



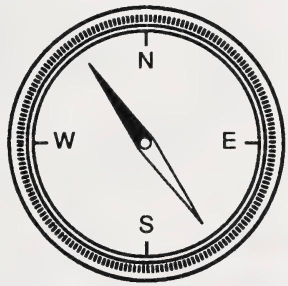
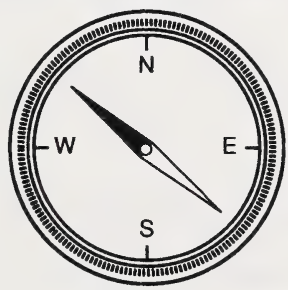
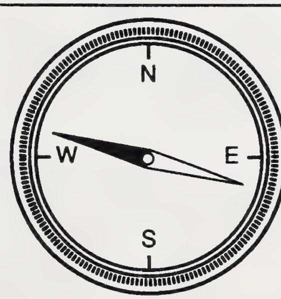
10. Indicate the position of the needle when the wire is wrapped only once around the compass and the wire briefly connected to the cell.



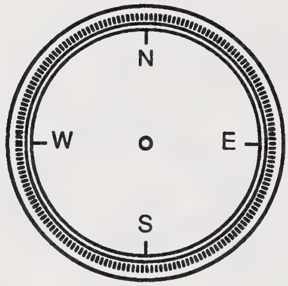
11. What is the position of the compass needle with the connection reversed?



12. Using the following data table, sketch and note the positions of the compass needle as wraps of wire are added.

Number of Wraps	**Compass Deflection (sketch position)**	**Notes**
2		
5		*deflection of compass increased*
10		*deflection of compass increased*

13. Sketch the position of the compass needle when a light is included in the circuit.



The sketch should show that the amount of deflection is less than what one would see in step 11 (question 12) for the same number of wraps of wire around the compass.

14. Do question 1 of Analysis on page 174.

The direction of deflection was reversed.

15. Do question 2. (a) of Analysis.

The amount of deflection increased as the number of turns of wire increased.

16. Do question 2. (b) of Analysis.

The needle did not deflect as far as it did in step 11.

17. Do question 3 of Further Analysis.

The evidence that an electrical current produces a magnetic effect is the needle deflection in the compass. The needle is sensitive to magnetic effects.

18. Do question 4 of Further Analysis.

The magnetic effect can be increased by increasing the number of turns of wire.

19. What is an ampere?

An ampere is a unit of measure. It measures the amount of current going through a given spot in a specific period of time. The symbol for ampere is A.

Section 1: Follow-up Activities

Extra Help

The following materials are needed for this activity:

- plastic strip, comb, or ruler
- plastic wrap or wool
- small piece of paper (6 cm × 15 cm) and tape
- two balloons
- thread

1. What caused the paper roll to be pulled across the table by the plastic strip?

   The plastic strip was charged and the paper roll was neutral, so they were attracted to each other. This attraction created a pulling force.

2. a. What happened to the two balloons?

      The two balloons repelled each other.

   b. Can you explain this?

      The two balloons were given similar or like charges that pushed or repelled each other.

3. Can static electricity exert a force? Explain your answer.

   Static electricity can exert a force. This investigation showed both pushing and pulling forces which could be seen to either move objects or oppose another force, such as gravity.

Enrichment

Students may do either Part A or Part B, or both.

The following materials are needed for this activity:

Part A

- plastic strip, plastic ruler, or plastic comb (as before)
- wool or plastic wrap
- aluminum foil
- glass rod
- silk cloth
- wooden ruler
- several hard-cover books

Part B

- plastic strip, plastic ruler or plastic comb (as before)
- wool or plastic wrap
- salt and pepper shakers

1. What did you observe happening to the foil?

   As you approach the aluminum foil strip with the charged rod, the ends of the strip open. When you move the charged rod away, the ends of the foil strip close.

2. What did you observe?

   The ends of the foil strip remained open.

3. If the plastic strip has a negative charge, the aluminum will now have a ___*negative*___ charge.

4. What did you observe happening to the foil?

   The aluminum foil strip ends close when the rod is brought close. When the glass rod is removed, the ends open.

5. The glass rod has a ___*positive*___ charge.

6. What did you observe?

   The pepper is attracted to the plastic strip.

7. Explain why this occurred.

   An imbalance of charge on the pepper grains can be created easily. This is a little more difficult with salt. The pepper grains are also lighter and require less force to lift them.

8. Where might industry use electrical forces in a similar manner?

   Some examples are:

   - *photocopiers*
   - *commercial spray-painting where the paint is negatively charged and the target has a strong positive charge. This reduces the amount of overspray.*
   - *Air purifiers in some homes create a zapping noise in the furnace as dust particles are removed from the air.*
   - *Industrial air-scrubbers remove dust from exhaust fumes, as in coal-fired thermal generating plants here in Alberta.*

Note: There is no assignment for Section 1 of this module.

Section 2: Cells and Batteries

In this section students will look at one of the most common sources of electricity – the battery. They will try to understand why batteries run out of energy after being used. The students will be given a chance to build a battery with a lemon and discover other materials that can be used for a battery. They will also start to see how they can control the flow of electricity by designing electrical circuits.

Section 2: Activity 1

The following materials are needed for this activity:

- two fresh lemons
- two other fruits or vegetables
- two large paper clips
- two 15 cm bare copper wires
- galvanometer, ammeter, or multimeter
- 250 mL beaker or similar container for water

This is very straightforward lab in which the students should be able to realize that in order to produce an electrical current, two different metals and a substance capable of conducting a current, in this case a fruit or vegetable, are needed. Copper wire from electrical wiring may be used as a source of bare copper wire, and nails may be used instead of paper clips. The nails should be sanded down to remove any oxides or coating to provide a good contact.

Caution: If students are using a multimeter, read Measuring Direct Current Strength (Amperage) under Measuring Electricity in the Appendix at the back of the module booklet for operating instructions. If students are using a different instrument, consult the operations manual for the particular instrument that they are using. They must follow the rules for safe operation to prevent damage to these instruments.

A moment may be taken here to explain the care and handling of the measuring equipment. Galvanometers are very sensitive and should not be bumped or dropped. Galvanometers measure small amounts of current in units called milliamperes (mA).

If students use a multimeter, the readings will be very low. A lemon will produce about 0.5 mA. When using these types of meters, start with the highest amperage setting on the meter. Then switch to lower settings until you get a reading. Students may also try the voltage scale to measure the volts produced. Do not use the ohms scale. A very high reading will be obtained, but this will be measuring the lemon's ability to allow electricity to flow through it. This is called conductivity, and has nothing to do with the lemon's ability to produce electricity. Make sure that the students sand down all contacts to ensure a good clean connection.

Other fruits that produce a potential difference are oranges, tomatoes, and grapefruit. A potato will work if you substitute a nail for the paper clip.

1. What is the problem for this investigation?

   The problem can be stated as follows: What causes a current and what determines its strength?

2. Record the number of divisions through which the needle moves on the galvanometer or the digital reading of the multimeter.

   The reading will be different, depending on the lemon, the materials, and the galvanometer being used. Sample reading: 0.5 mA.

3. Use the following data table to record the number of divisions through which the needle moves on the galvanometer or the digital reading of the multimeter.

The results will vary, depending on the fruit or vegetable and instrument being used.

Data: Comparing the Ability of Different Materials to Produce Current Electricity		
Substitution	**Instrument Reading**	**Comments**
copper wire for paper clip	*0*	*no current*
paper clip for copper wire	*0*	*no current*
________ for lemon	*Answers will vary.*	
________ for lemon	*Answers will vary.*	
________ for lemon	*Answers will vary.*	
tap water in a cup for lemon	*0*	*no current*

4. Complete question 1 of Analysis on page 177 of your textbook.

   Textbook question 1. (a):

   The strongest current was produced with the lemon, copper wire, and paper clip.

   Textbook question 1. (b):

   The weakest current was produced with two like materials inserted into the fruit or vegetable.

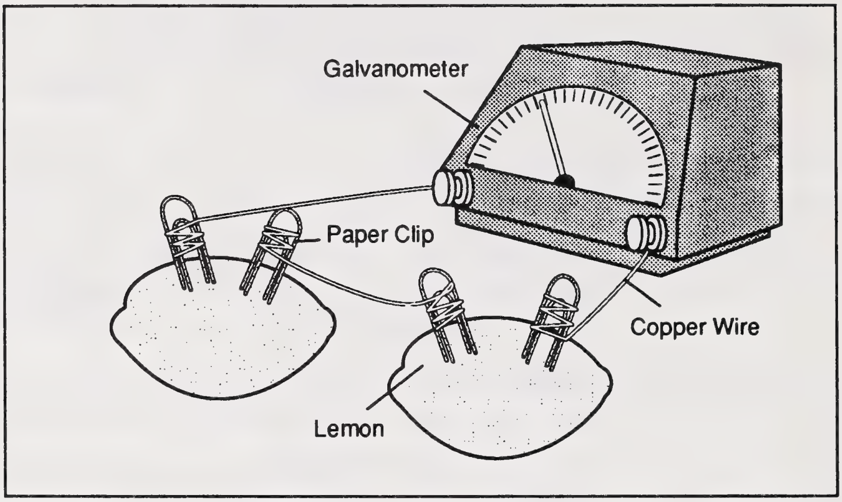
5. Do question 2 from Further Analysis.

   You need two different metals and an acidic substance to produce an electric current.

6. Do question 4 of Extension.

   Draw the connections between the two lemons and the galvanometer or multimeter in the following space. Show the instrument reading in the diagram and label all parts of the circuit.

   The following drawing shows the best combination for the highest current output.



Section 2: Activity 2

Students may do either Part A or Part B.

The following materials are needed for the first investigation:

Part A

- voltmeter or multimeter
- two connecting wires with alligator clips
- electrode holders
- carbon rod or strip
- zinc strip
- 250 mL beaker
- 200 mL of each of following liquids
  - tap water
  - salt solution
  - sugar solution
  - vinegar
  - soap solution

Part B

- voltmeter or multimeter
- two connecting wires with alligator clips
- zinc strip
- carbon rod
- 250 mL beaker or glass jar
- a plastic lid from a food container (the same diameter as the beaker or slightly larger)
- 200 mL of each of the following liquids
  - tap water
  - salt solution
  - sugar solution
  - vinegar
  - soap solution

The following materials are needed for the second investigation:

- voltmeter or multimeter
- 250 mL beaker
- one strip or rod of each of the following materials
  - iron
  - aluminum
  - copper
  - zinc
  - carbon

> **Caution:** If students are using a multimeter, read Measuring Direct Current voltage under Measuring Electricity in the Appendix at the back of the module booklet for operating instructions. If they are using a different instrument, consult the operations manual for the particular instrument that they are using. They must follow the rules for safe operation to prevent damage to these instruments.

To prevent severe damage to the galvanometers, make sure the students connect the positive and negative ends of the cell to the positive and negative ends of the galvanometer. If the meters have a variety of terminals, connect to the highest scale first. If no reading occurs, reconnect to the next highest scale. Continue this until the students get a reading on their meter.

Electrode holders are not important as long as the metal strips are held an equal distance apart at all times. They must not touch. Ensure that the electrodes are clean. They may need to be sanded with a fine emery cloth if they are dirty.

1. How does an electrical cell produce an electrical current?

   An electric cell produces an electric current by converting chemical energy into electrical energy.

2. In the previous investigation you connected two lemons together. This is the same as connecting two *cells* to make a *battery*.

3. If your radio takes four D-size 1.5 V cells, the total voltage of the batteries within the radio is *6 V*.

4. What device is used to measure the voltage of a battery?

   A voltmeter is used to measure the voltage of a battery.

5. Write a short paragraph that explains how to connect a voltmeter or a multimeter to a power source.

   When connecting the voltmeter to a store-bought cell, ensure that the positive post of the meter is connected to the positive terminal of the battery and that the negative post is connected to the negative terminal of the battery. Refer to Measuring Direct Current Voltage in the Appendix of the module booklet for the operation of a multimeter to determine voltage, or, if using a different instrument, check to see that the student's answer agrees with instructions given in the operations manual for that instrument.

6. What symbols are used on the galvanometer to show the positive terminal and the negative terminal?

   positive terminal: +

   negative terminal: –

7. What is the problem for this investigation?

   The problem can be stated as follows: Which of the suggested liquids is best for making an experimental cell?

8. Use the following data table to record the voltmeter reading for each of the liquids used.

   Answers will vary, depending on the concentration of the liquid. The salt and vinegar solution should give you the highest readings. Tap water will give a reading if there are impurities present. Distilled water will not. Sample data is included for comparison with the students' results. The data table with sample data is shown at the top of the next page.

Data Table: Different Types of Liquid Versus the Voltage Produced		
Liquid Used	**Voltmeter Reading**	**Comments**
Tap Water	*0.5*	
Salt Solution	*1.0*	
Sugar Solution	*0.5*	
Vinegar	*1.0*	
Soap Solution	*0.7*	

9. Which liquid gave the highest reading on the voltmeter?

   Answers will vary, depending on the concentration of the liquid used. The salt and vinegar solution should give the highest readings.

10. To ensure that the test was fair, what conditions did you have to keep constant?

    The same two strips had to be used, the distance between the strips had to be the same, and the level of the liquid had to be kept the same.

11. What is the problem for this investigation?

    The problem can be stated as follows: What metal, or combination of metals (from those available), is best for making an experimental cell?

12. Use the following data table to record the voltmeter reading for each combination of metals used.

    Answers will vary. Again, this is due to the concentration of the solution. Another factor that will effect the reading is how clean the metal strips are. Sample data is included for comparison with students' results. The table with sample data is shown on the next page.

Data: Voltage Produced by Different Electrodes		
Metal Combination	**Voltage Reading**	**Comments**
carbon/zinc	*1.0*	
carbon/copper	*0*	
carbon/aluminum	*0.5*	
carbon/iron	*0.9*	
zinc/copper	*0.8*	
zinc/aluminum	*0*	
zinc/iron	*0*	
copper/aluminum	*0.5*	
copper/iron	*0*	
aluminum/iron	*0*	
copper/copper	*0*	

Comment:

If students are able to get two strips or rods of each type of metal, they should test the voltages produced by using two similar metals such as iron/iron or copper/copper. They should find that if this is done, the voltage readings are zero, or at best very low, if the metals contain impurities, thereby reinforcing the idea that for current to be produced metals of different kinds are needed for the cell.

13. Which pair of metals gave the highest voltmeter reading?

    Answers will vary, but the best combinations may be carbon and zinc, copper and zinc, and carbon and iron.

14. To ensure that the test was fair, what conditions had to be kept constant in this investigation?

    The plates had to be the same size and thickness and had to be the same distance apart, and the same solution had to be used all the time.

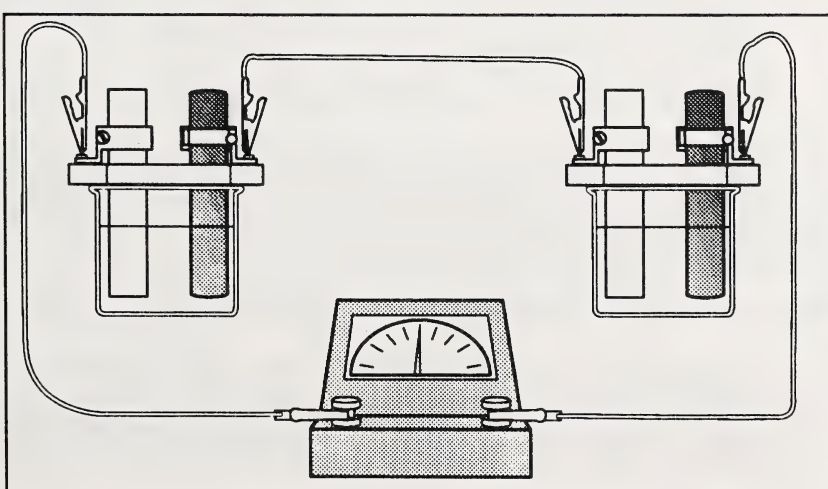
15. Complete question 3 of Further Analysis on page 180 of your textbook.

    The answer will vary, depending on the solutions and plates used. The main thing for students to realize is that they need two metal strips made of different materials and a suitable solution.

16. Now try to connect two of these cells together to get the highest voltage output. Draw the connection and show the galvanometer reading.

    By connecting the terminals in series, positive to negative, or from one metal strip of one cell to the opposite type of metal strip of the second cell, the voltage will be increased.

    Students drawings may vary to reflect the varieties of equipment used.



17. When you connect two or more cells together, you create a *battery*.

18. How many cells does the car battery contain?

    On a 12 V car system, there are six cells, one for each of the filler caps. On the sealed units, you can look at the side where you can see the cell walls. Each cell produces 2 V.

Section 2: Activity 3

Comment:

Caution students not to take batteries or cells apart. The electrolyte in most batteries and cells is caustic.

1. What are the two common features found in all cells?

   The two common features found in all cells are two different types of metal and a solution that surrounds the two metals.

2. What are electrodes?

   Electrodes are the metal strips found in a cell.

3. What is an electrolyte?

   An electrolyte is the solution in a cell.

4. Draw a simple diagram of a zinc carbon cell in the following space. Explain how the cell works. If you do not like to draw, then write an explanation that clearly explains how an electrical current is produced. You may do both if you wish.

   Refer to the illustration on page 181 of Science Directions 9 for a diagram of a zinc-carbon cell.

   A chemical reaction within the cell occurs, causing a build-up of negative charges on the zinc electrode. At the same time, the carbon electrode loses negative charges. When the two terminals are connected with a wire, the negative charges move from the zinc electrode to the negative electrode, producing a current.

5. What makes the rechargeable battery different from the zinc carbon cell?

   The main difference between a rechargeable cell and a zinc-carbon cell is that the chemical reaction in a rechargeable battery can be reversed. Electricity can be stored as chemical energy in a rechargeable battery. This requires a special electrolyte and special electrodes. Never try to recharge a non-rechargeable battery!

6. What design features would be needed in a battery for each of the following situations?

   a. spacecraft: *lightweight, small, sensitive, long lasting*

   b. heart pacemaker: *lightweight, small, long lasting, unaffected by microwaves so that it does not affect the timing of the pacemaker*

   c. car powered only by batteries: *quickly rechargeable, long lasting, large current output for a long period of time*

Section 2: Activity 4

The following materials are needed for the first investigation:

- two D-sized batteries in a holder (Students may make this using the instructions in their booklet.)
- one D-sized battery in a holder
- 1.5 V bulb
- 2 V bulb
- 3 V bulb
- one socket for the bulbs
- two connecting wires with alligator clips

The following materials are needed for the second investigation:

- two D-sized cells in a holder
- 3 V bulb and socket
- two connecting wires with clips
- 50 cm fine nichrome wire
- 50 cm fine bare copper wire
- ammeter or multimeter

Any three bulbs with voltage requirements under 4.5 V will do for these investigations.

Caution: If students are using a multimeter, read Measuring Direct Current strength (Amperage) under Measuring Electricity in the Appendix of the module booklet for operating instructions. If students are using a different instrument, consult the operations manual for the particular instrument that they are using. They must follow the rules for safe operation to prevent damage to these instruments. Do not allow students to proceed with measurements without the approval of you, the learning facilitator.

When measuring amperage from a cell, a resistance, such as a light bulb, must be included in the circuit. Please check that students are aware of this fact before they use their instruments.

Comment:

Connecting batteries in series will increase the voltage. Series is where the positive terminal is connected to the negative terminal of the second cell. This is the way the battery holder connects the cells. So, instead of 1.5 V, you now have 3 V. In step 3 of the procedure, the only way to light the bulb is by placing the two cells in series.

1. What is the problem for this investigation?

   The problem can be stated as follows: How can you make a simple flashlight?

2. In your own words, make a prediction as to how current and bulb brightness are related.

   Students may predict that a brighter bulb will require more current.

3. Use the following data table to record the relative brightness of the bulbs.

   Current measurements may vary from those shown, but the higher the nominal voltage of the bulbs, the lower the current should be.

Bulb Type	Brightness	Instrument Reading
1.5 V	*bright*	*0.38 A*
2 V	*weak*	*0.21 A*
3 V	*nothing*	*0.11 A*

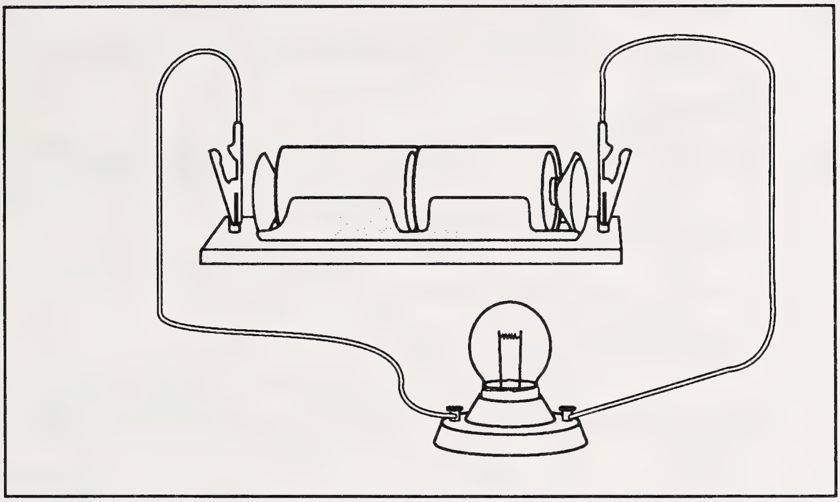
4. Use the table in question 2 to record the current measured.

   See the table in the preceding question.

5. What is the relationship between the bulb brightness and current? Was this as you predicted?

   The brighter the light bulb, the greater the current. This may or may not have been predicted.

6. Draw the arrangement that you used for step 3 of the procedure.



Note: Although the 1.5 V bulb will be brightest in this circuit, it should be pointed out that such an arrangement will shorten the life of the bulb.

7. What is the problem for this investigation?

   The problem can be stated as follows: How can you vary the brightness of your flashlight?

8. Record what happens to the brightness of the bulb.

   As the clips are moved further apart, the light bulb becomes dimmer. When the clips are moved closer together, the light bulb becomes brighter.

9. Place your hand close to the nichrome wire. What do you notice?

   Students should notice that the nichrome wire is giving off heat.

10. What happened to the brightness of the bulb when a copper wire was used?

    The light bulb maintains the same brightness and there is no heat produced when a copper wire is used.

11. As electricity flowed through the light and the nichrome wire, what two forms of energy could you observe?

    As electricity flowed through the nichrome wire, you could observe heat and light energy.

12. Do question 1 of Analysis on page 183 of your textbook.

    Textbook question 1. (a):

    The light bulb was brighter with two batteries hooked in series.

    Textbook question 1. (b):

    The further apart the clips were, the dimmer the light bulb became.

13. Do question 2 of Further Analysis.

    Copper wire allows more current to pass.

14. Do question 3 of Further Analysis.

    To increase the amount of current flowing through a nichrome wire, you must shorten the length.

15. Do question 4 of Further Analysis.

    You would use copper wire, rather than nichrome wire, and two cells, rather than one, to provide more electricity.

16. What is a resistor?

    A resistor is any device made of a certain material that will resist the flow of electricity through it.

17. Use the idea of resistance to briefly explain how one of the following items works.

    - light bulb
    - electric kettle
    - oven
    - toaster

    All of the items listed use materials that have a high resistance to the flow of electricity. When electricity flows through the material, the electrons give up some of their energy to the material in the form of heat.

18. In what devices would you find a variable resistor, or rheostat? At the same time try to explain what they do.

    You will find a variable resistor or rheostat in any of the following items:

    - *a dimmer switch which controls the brightness of a light bulb*
    - *volume controls on a radio or television*
    - *speed controls on electric motors*

Section 2: Follow-up Activities

Extra Help

Students may do either Part A or Part B, or both.

Part A is a straightforward investigation, similar to Activity 4-4 on pages 179 and 180 of the textbook. Part B is also a straightforward investigation, similar to Part B of Activity 4-5 on page 183 of the textbook.

The following materials are needed for this activity:

Part A

- galvanometer, voltmeter, or multimeter
- connecting wires without clamps
- tape
- rubber band
- paper towel
- salt solution
- two zinc metal strips
- two copper metal strips

If zinc and copper strips are not available, students may try using dimes and pennies separated by pieces of paper towel soaked in salt solution.

Part B

- connecting wires with clips
- two D-size cells in a holder
- 3 V light bulb in a holder
- soft lead pencil (such as HB)
- knife

Caution students about the use of a knife. You may wish to strip the pencil for them.

1. What is the amount of deflection of the needle on the galvanometer or the reading on the ammeter?

   The amount of deflection will depend on the concentration of the solution, the sensitivity of the instrument used for measuring, and how clean the metal strips are. If a galvanometer is used, the measurements will be in milliamperes. If a voltmeter is used, the measurements will be in volts. A reading of 1 V to 1.5 V is very good.

2. What is the amount of deflection of the needle on the galvanometer or the reading on the ammeter?

   Again the strength will vary, but the student should get double the needle deflection found in question 1 when using a galvanometer. If a voltmeter is used, a reading of 2 V to 3 V is excellent.

3. How does your answer in question 1 compare with the answer in question 2?

   The reading in question 2 should be double that in question 1.

4. The single "sandwich" is referred to as a cell. What would the "double sandwich" be called?

   A "double sandwich" would be a battery.

5. In the dry cell, ___*chemical*___ energy is being converted into ___*electrical*___ energy.

6. For a cell to work, the electrodes must consist of two ___*different*___ metals and an ___*electrolyte*___.

7. To make a battery, you would connect the positive terminal of one cell to the ___*negative*___ terminal of another cell.

8. Slide the free clip up and down the exposed pencil lead. Record what you observed.

   The further apart the clips are, the dimmer the light becomes.

9. Why did the light bulb grow brighter and dimmer?

   The pencil lead has a high resistance to the flow of electricity. The longer the conducting length of the pencil, the higher the resistance. The greater resistance reduced the amount of electricity that flowed through the bulb.

10. What do you think would happen if you used copper wire instead of a graphite pencil?

    The brightness of the light would not change if copper wire was used instead of a graphite pencil.

Enrichment

The following materials are needed for this activity:

- large test tube
- 50 cm nichrome wire
- four D-sized cells connected in series or a 6 V dry cell
- glass tubing or a straw
- water
- support stand and clamp or tape
- thermometer
- two connecting wires with clips

Note: Students may tape their test tube to a suitable upright support, rather than using a support stand.

Caution: Warn students that the nichrome wire can get very hot.

Comment:

A possible extension to this activity would be to graph the data.

1. What is the problem for this investigation?

   The problem can be stated as follows: How can you heat water by means of an electric current?

2. Use the data table on the next page to record temperature.

   Results will vary, depending on the starting temperature, altitude, number of turns in the nichrome wire, and the output of the batteries. The following sample data is provided for comparison with students' results. The data table is shown on the following page.

Data: Rate of Temperature Increase Due to Current Through a Nichrome Wire

Time (min/sec)	Temperature °C	Comments
0:00	*19*	
0:30	*20*	
1:00	*21*	
1:30	*22*	
2:00	*22.5*	
2:30	*23*	
3:00	*24*	
3:30	*24.5*	
4:00	*25*	
4:30	*26*	
5:00	*27*	

3. Complete question 1 of Analysis.

   Check students' data tables to see if they have interpreted it correctly.

4. What property of the nichrome wire allowed you to heat up the water?

   Nichrome wire has a high resistance to electricity, therefore, it will heat up when electrical current goes through it.

5. Name some household appliances that use this same property.

   Answers may include any device that uses heat as part of its function. (e.g., stove elements, toasters, and light bulbs)

Section 2 Assignment

Marking Guide: Suggested values are given in brackets.

1. Complete question 3 of Checkpoint on page 185 of your textbook.

   Textbook question 3. (a): (2 marks)

   The essential components of a chemical cell are an electrolyte and two electrodes made of different metals.

   Textbook question 3. (b): (3 marks)

   Both the first and fourth cells would not work because both electrodes are made from the same metal. The second cell would have a very weak current because sugar solution is a poor electrolyte.

2. Complete question 4 of Checkpoint on page 185 of your textbook. (3 marks)

   - *An ammeter measures current strength in amperes or milliamperes.*
   - *A voltmeter measures the force that creates an electric current in volts.*
   - *A galvanometer measures weak electric current strength in milliamperes. (Accept the answer amperes but point out to the student that the galvanometer measures in smaller units called milliamperes.)*

3. Complete question 6 of Checkpoint on page 185 of your textbook. (2 marks)

   Because the bulbs glows less brightly using metal X than copper wire, metal X has a higher resistance than copper wire.

4. Complete question 7 of Checkpoint on page 185 of your textbook.

   Textbook question 7. (a): (1 mark each – 4 marks total)

   The following list of the components is needed to create a living-room light with a variable brightness.

   - *bulb*
   - *wires*
   - *power source*
   - *device to control resistance – this is the most important factor to look for in the student's answer.*

   Textbook question 7. (b): (1 mark)

   The main problem to be concerned with is the amount of heat that would be produced. If the resistor (rheostat) is put into a limited space within the lamp without proper ventilation, overheating may occur, resulting in a fire.

Section 3: Generating Electricity

The focus of this section is the production of electricity using other energy sources. Students have already seen that electricity can be produced by using chemical energy from a battery. In this section the generator provides an example of the technology used to convert mechanical energy into electrical energy. Students will also see that energy conversions can be reversed as they examine an electric motor. They will determine the role of magnetism and electromagnets in this process. They will then look briefly at technologies for generating electricity from heat, solar energy, and sound.

Section 3: Activity 1

The following materials are needed for this activity:

- emery cloth or fine sand paper
- small knife for removing insulation
- magnet
- 10 m of insulated 26 gauge copper wire
- tape
- galvanometer, ammeter, or multimeter
- cardboard tube from paper towel or toilet paper roll

The investigation in this activity works well when a galvanometer is used since only weak currents are produced, but, if a galvanometer is not available, students may try using an ammeter or a multimeter in place of a galvanometer. Also, if 26 gauge insulated copper wire is not available, then 24 gauge or 28 gauge wire may be used.

If you have access to a local power company, you may wish to arrange a tour of their facilities at the end of this section. The videotape *Electricity* is included as an alternate pathway when introducing this topic.

1. How is most of the electricity that you use in your house produced?

   Most of the electricity used in houses is produced by generators.

2. Batteries convert chemical energy into electrical energy. Another way of making electricity is by converting ___*mechanical*___ energy into ___*electrical*___ energy.

3. What is the problem for this investigation?

   The problem can be stated as follows: How can a magnet and coil of wire be used to produce a current? Students may state this in their own words.

4. Use the following data table to record the galvanometer readings. You may use the information given under question 1 of Analysis as a guide on how to complete the table. (If you are using a digital multimeter instead of a galvanometer, your readings may be stated in numerical values.) Describe how you moved the magnet around the coil. The first example is given.

   Student answers will vary. Readings depend on the strength of the magnet, how fast you move it, the gauge of the wire, the insulation, and how big the coil is. When the magnet is moved slowly, there should be no reading, or a very weak one. When the magnet is outside the coil, there should also be no reading or a very weak one. When the magnet is inside the coil and either the magnet or coil is moved quickly, the reading should be strong. By increasing the number of turns of wire, the voltage can be increased even more. The following table contains sample data, using a galvanometer and a system of recording as suggested in question 1 of Analysis on page 187 of the textbook. If a digital multimeter is used, the results will be recorded as numerical values.

Data: Comparing the Position of the Magnet and the Amount of Current Produced in the Coil

Position and Movement of Magnet	Instrument Reading	
	50 turns (step 2)	___*75*___ **turns (step 8)**
north pole outside coil moved slowly	*0*	*slight –*
south pole outside coil moved slowly	*0*	*slight +*

Data: Comparing the Position of the Magnet and the Amount of Current Produced in the Coil		
Position and Movement of Magnet	**Instrument Reading**	
	50 turns (step 2)	**_75_ turns (step 8)**
south pole outside coil moved quickly	*slight +*	+
north pole outside coil moved quickly	*slight –*	–
norht pole inside coil moved out slowly	–	–
north pole inside coil moved in quickly	+ +	+ +
south pole inside coil moved in quickly	– –	– –
south pole inside coil moved out slowly	+	+
south pole inside coil moved in slowly	–	–
north pole inside coil moved out quickly	– –	– –

Comment:

Some multimeters are not sensitive enough to give readings due to the weak currents produced, or, because of a built-in delay mechanism in displaying results, they don't react quickly enough to current impulses of short durations. If your students were unsuccessful in getting results, then discuss the sample results shown in the previous table.

5. Does it matter if the bar magnet or the coil moves?

   It does not matter which is moving, as long as either the bar magnet or the coil is in motion.

6. Complete question 2 of Further Analysis.

   A current can be obtained by either moving a bar magnet in and out of the coil or by moving the coil very rapidly with the bar magnet inside it.

7. Do question 3 of Further Analysis.

   In order to get a continuous supply of electrical current, you must keep either the bar magnet or the coil rapidly moving back and forth.

8. Do question 4 of Further Analysis.

   To increase the current you can do any of the following three things:

   - *Increase the strength of the bar magnet.*
   - *Increase the number of turns of wire.*
   - *Increase the speed of movement.*

Section 3: Activity 2

Students may do either Part A or Part B.

The following materials are needed for this activity:

Part A

- small hand-held generator
- 3 V bulb in a socket
- two connecting wires with clips
- galvanometer, ammeter, or multimeter

Part B

No materials are needed.

Test the generator before allowing your students to experiment with it. The electrical output of the generator may be too high or too low for the bulb. Remind students to use the highest scale of the galvanometer first and then change to lower scales until they have a reading on the meter.

Be careful when using old-style hand generators. The output of these generators can be very high.

Note: You may think that an electric motor can also be used. In testing, however, it was found that a 9 V electric motor was barely sufficient to achieve flickering in a 1.5 V 25 mA bulb. If you choose to use a motor in place of a generator, keep this in mind.

1. Do steps 1 and 2 of the procedure. Then record your results.

   As you increase the speed of the generator, the light bulb becomes brighter.

2. Do step 3 of the procedure. Then record your results.

   As you increase the speed of the generator, the galvanometer's reading becomes higher. When you change the direction of the generator, the needle goes in the opposite direction.

3. Do question 1 of Analysis on page 188.

   You can make the light bulb brighter by speeding up the motion of the generator. To make the light bulb dimmer, you would slow down the generator.

4. Do question 2 of Analysis.

   As long as the generator is turning at the same speed, there will be no difference in the brightness of the bulb when the direction is reversed.

5. Based on what you learned in the last two investigations, what do you think are the two main components in a generator?

   The two main components in the generator are the magnet and the coil of wire.

Section 3: Activity 3

The following materials are needed for this activity:

- compass
- 2 m of insulated 26 gauge copper wire
- two D-size cells in holders
- two connecting wires with clips
- pencil
- iron spike
- fifty or more small finishing nails

Students will experience a lot of success in this simple activity.

In step 8, have the students hold the magnet over a container. This will make cleanup easier.

If your students wish to make a stronger electromagnet, they will need some 32 gauge copper wire and a good piece of soft iron, which you should be able to get from a machine shop. A possible project for a group of students is to see who can design and build the strongest electromagnet using only 3 V.

Some practical applications of the electromagnet are:

- the separation of magnetic particles from non-magnetic particles (e.g., the refining process of certain minerals)

- switches and relays (This will be dealt with in Section 4.)

1. What are the two different types of magnets?

   The two types of magnets are the permanent magnet and the electromagnet.

2. What is the problem for this investigation?

   The problem for this investigation may be stated as follows: How can you make and use a strong electromagnet?

3. Record how many degrees the compass needle deflected from its north-south position.

   This will vary, depending on the strength of the battery and the gauge of the wire. You should be able to get anywhere from a 45° to 90° deflection.

4. What did you observe with the iron spike?

   The needle deflection is greater when you use the iron spike.

5. What did you observe when you doubled the number of turns of wire?

   When you doubled the turns of the wire, the deflection of the compass needle became greater.

6. What did you observe with forty turns of wire and one extra electrical cell?

   When another cell was added and you increased the windings, the magnet became stronger. There was a greater deflection of the needle.

7. How could you improve on your electromagnet to increase its lifting strength?

   You can increase the lifting strength of an electromagnet by doing any of the following things:

   - *Increase the number of coils.*
   - *Use a large spike.*
   - *Add more cells.*

8. Do question 3 of Further Analysis.

   An electromagnet has the following advantages over a permanent magnet:

   - *varying the strength of the magnetic field*
   - *turning the magnet off and on when needed*

Section 3: Activity 4

There are two points that students should realize in order to understand how a motor works. The first point is that like poles of magnets repel each other. The second point is that by reversing the current in an electromagnet, you reverse the poles.

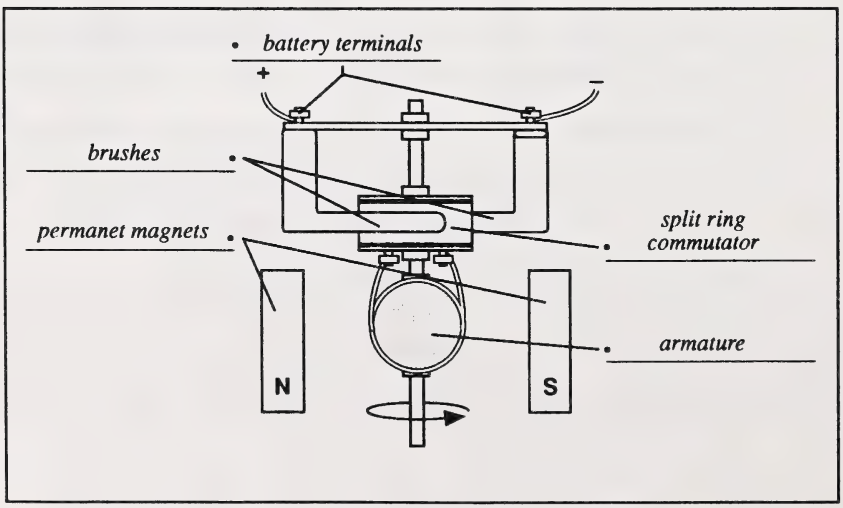
1. As you read the passage in your text, you found out that electromagnets have a north and south pole. What happens to the poles if you reverse the direction of current flowing through the electromagnet?

   The north and south poles of the electromagnet will reverse if the current is reversed.

2. The armature is the same as an *electromagnet*.

3. Label the diagram using the following terms.

   - permanent magnets
   - armature
   - brushes
   - split ring commutator
   - battery terminals



4. Assume that electricity moves from the negative terminal to the positive terminal. Describe the path of electrical current from one battery terminal to the other terminal when the brushes are in contact with the metal in the commutator. You may wish to use a flow diagram.

→ = electricity

negative terminal

↓

brush

↓

metal of the commutator

↓

wire of the B side of the armature

↓

A side of the armature

↓

metal of the commutator

↓

brush

↓

positive terminal

5. As the current begins to flow through the armature, End A becomes the ___*north*___ pole.

6. What happens to the armature? Explain.

   End A of the armature is repelled by the north end of the permanent magnet. End A of the armature is also attracted by the south pole of the other magnet. This causes the north pole of the armature to move towards the south pole of the magnet.

7. As the armature turns, the brushes come in contact with the insulating gap. Is there any current flowing through the armature at this time?

   There is no current flowing.

8. As the armature turns further around, the brushes come in contact with the other side of the split ring metal commutator. What happens to the direction of current flow in the armature?

   The current flow in the armature is reversed.

9. End A of the armature now becomes the ___*south*___ pole.

Section 3: Activity 5

The following materials are needed for this activity:

- 20 cm of bare thick copper wire
- 15-cm iron coat hanger (with coating removed)
- two connecting wires with clips
- galvanometer, ammeter, or multimeter
- heat source
- pliers to hold the thermocouple
- a container of cold water

Candles may be used as a heat source, but they will cover the thermocouple with soot – a bunsen burner or alcohol burner is preferred. If none of these items are available, use a stove-top element. Higher temperatures will produce higher readings.

Caution the students of the dangers of open flames and other heat sources. Remind students that the metal will cause severe burns if they are not careful. They should not do this activity without supervision.

1. What does a thermocouple do?

   A thermocouple is a device that converts heat energy into electrical energy.

2. Record the results from steps 3 to 5 in the following table.

Sample readings are given. Students' data will vary, mainly due to the metal being used and the sensitivity of the meter.

Data: Current Produced by Thermal Effects		
Steps	**Instrument Reading**	**Comments**
3 (before heating)	*0 mA*	
4 (while heating)	*0.3 mA*	*remains steady*
5 (while cooling)	*0 mA*	*slowly drops*

3. Do question 1 of Analysis.

The two factors that affect the current produced by the thermocouple are the properties of the two metals and the amount of heat.

4. Do question 2 of Analysis.

"Thermo" means "heat" and "couple" means "a combination of two".

5. Does a thermocouple produce a lot of electricity?

Thermocouples produce very little electricity.

6. Make a list of some practical applications for a thermocouple.

Thermocouples are used to record temperature. They are used mainly in areas where there are high temperatures. Commercially, they are used in large furnaces. The oven in your house also has a thermocouple.

Section 3: Follow-up Activities

Extra Help

The following materials are needed for this activity:

- a simple electromagnet made from a nail with twenty turns of thin insulated copper wire wrapped around it

- a compass

- two connecting wires with clips

- one D-size cell with holder

1. Which end of the compass needle points to the nail?

   The answer should mention that either the light coloured end of the needle or the dark coloured end of the needle pointed to the nail.

2. Which end of the nail does the needle point to now?

   The answer should be opposite to that of question 1.

   The needle still pointed to the nail, except now the opposite end of the compass needle pointed to the nail.

3. What happens to the poles of an electromagnet when the current is reversed?

   The poles of the electromagnet are reversed when the current is reversed.

4. Write a paragraph to briefly explain how an electric motor works.

   Students can use pages 190 and 191 of the textbook as the source of information to answer this question. The following five main parts should be mentioned within their paragraphs.

   - *permanent magnets*
   - *armature*
   - *insulation gap*
   - *brushes*
   - *split ring commutator*

   They should also mention the reversing of poles in the armature and the repulsion of like poles.

Enrichment

Students may do either Part A or Part B, or both.

The following materials are needed for this activity:

Part A

- reference materials on solar energy

Part B

- galvanometer, ammeter, or multimeter
- solar cell
- small battery-powered light source (flashlight)
- metre stick or tape measure
- two connecting wires (1/2 metre each)

Solar cells may be obtained from electrical supply stores and from discarded solar calculators.

This is a good activity for students to graph their results.

If there is more than one group doing this investigation, have them shield their set-up using textbooks standing on end. A low wattage light bulb can be substituted for the battery-powered light.

1. Where do people use solar energy?

   We use solar power for calculators, heating buildings, for recharging batteries in remote areas, and in satellites.

2. What is the problem in this investigation?

   The problem can be stated as follows: How can electrical energy be obtained from solar energy? Students may write this in their own words.

3. What was the reading on the galvanometer with the light on?

   The answers will vary, depending how bright the light is and how sensitive the solar cell is. A sample reading is 1.5 mA.

Comment:

If a voltmeter is used instead of a galvanometer the readings will be in volts instead of milliamperes.

4. What was the reading on the galvanometer with the solar cell covered?

   The answer will be 0 mA since there is no light coming in.

5. Use the following data table to record your results. Specify the units of measurement.

   There is an inverse square relationship between the electrical energy produced and the distance the light source is away from the solar cell. Theoretically, if you double the distance, the current output will be quartered. This is not a concern for the students to know. As you can see in the following sample data, the further the distance from the light source, the lower the current reading.

Data: The Effect of Distance from a Light Source on the Electrical Current Produced by a Solar Cell	
Distance of Light Source (cm)	**Instrument Reading**
20	*5 mA*
40 (double)	*3 mA*
60 (triple)	*1 mA*

6. What was the reading on the galvanometer with two light bulbs?

   The reading should almost be the same as the first. In the sample data it was 5 mA.

7. Do question 1 of Analysis.

   The factors that determine how much electricity is produced are the intensity of the light and the distance from the light source.

8. Do question 2 of Analysis on page 197 of the textbook.

   Advantages of solar energy:

   - *lightweight*
   - *no moving parts to wear out*
   - *pollution free*

Disadvantages of solar energy:

- *expensive to build*
- *large number of cells to produce a small amount of electricity*
- *can only be used under sunny weather conditions*

9. Do question 3 of Further Analysis.

   Solar cells are practical in space because they are reliable. They have no moving parts, therefore, they do not wear out. Also, the sun always shines in space.

10. What is the proper name for the conversion of sound waves into electrical current?

    The proper name for converting sound waves into electrical energy is called the piezoelectric effect.

11. What devices do you use that convert sound wave into electrical energy, or electrical energy into sound waves?

    Examples of devices that convert sound into electrical energy, or the reverse, electrical energy into sound, are microphones, record players, radios, telephones, and speakers.

Section 3 Assignment

Marking Guide: Suggested values are given in brackets.

1. Complete question 2 of Checkpoint on page 199 of your textbook. (3 marks)

   Three ways to improve the strength of the electromagnet are to use an iron nail or a soft iron core, increase the number of turns of wire, or increase the voltage.

2. Complete question 3 of Checkpoint on page 199 of your textbook. (10 marks)

Part Number	Part Name	Function
1	*connections or terminals*	*The connections or terminals are used to connect the motor to a power source.*
2	*brushes*	*The brushes allow the electricity to pass from the terminals to the commutator.*
3	*commutator*	*The commutator turns so that the brushes can either touch the metal ring or the insulating gap at the right time.*

Part Number	Part Name	Function
4	*armature*	*The armature is the moving part that is connected to the item doing the work. This is the electromagnet.*
5	*permanent magnet*	*The permanent magnet attracts and repels the armature.*

3. Complete question 4 of Checkpoint on page 199 of your textbook. (2 marks)

   The students may suggest checking the batteries to be sure that there is adequate charge to operate the motor. The condition of the brushes and other contact points should also be checked. Students who are familiar with this motor might also suggest flicking the armature to see if it needs a boost of momentum to get it started.

4. Give five examples of different technologies that can be used to produce electric current. What is the energy source in each case? (5 marks)

   - *battery – chemical energy*
   - *generator – mechanical energy*
   - *photoelectric cell – solar (light) energy*
   - *thermocouple – heat energy*
   - *piezoelectric crystal – sound energy*

Section 4: Circuits and Switches

In this section students will focus on controlling electricity. They will build and experiment with series and parallel circuits to gain an appreciation for the difference between them. The students will also learn basic symbols used in circuit diagrams. This section is the foundation for some problem-solving activities in the next section.

Section 4: Activity 1

The following materials are needed for this activity:

- two D-size cells in a battery holder
- three 3 V lamps in holders
- push-button switch or scissor switch
- four connecting wires with clips

This activity introduces a lot of new vocabulary words. Make sure the students understand the words.

Any type of switch will work, including a normal light switch or a doorbell button. However, it is better if the student can see the contacts open and close. Homemade switches work very well. Look at Activity 2 if you wish to have students make this type of switch.

The students are expected to understand the results of hooking items up in series or parallel circuits. The theory behind parallel and series circuits is related to the amount of resistance. By adding a bulb in a series circuit, you increase the resistance along the circuit, thus reducing the amount of current or electricity that is able to flow through it. When you add another bulb to a parallel circuit, you add another path for the electricity to flow, thus the total resistance decreases. The current from the cells in a parallel circuit is increased because there is less resistance to the flow. A circuit hooked in parallel will drain the battery a lot faster. This is why some Christmas lights are hooked in series. They use less electricity.

> **Caution:** Do not let students hook more than two cells together in series with one light bulb. Any more cells will burn out the light.

1. Define the following terms.

   a. electric circuit: *a pathway through which the electricity can flow from the source and back to the source*

   b. open circuit: *a pathway that has a break in the circuit and the electricity cannot flow*

   c. closed circuit: *a pathway that does not have a break in the circuit and the electricity can flow*

   d. switch: *a device that can open and close a circuit*

2. Define the following subsystems found in an electrical circuit system.

   a. source: *any device that converts one energy form into electrical energy (e.g., cell, battery, generator, plug)*

   b. conductor: *a material that allows the electricity to travel along a pathway (e.g., copper wire)*

   c. control: *a device which starts and stops the flow of electricity (e.g., switch)*

   d. load: *a device that changes electrical energy into another form of energy (e.g., light bulb, stove element, motor)*

3. In your own words describe the difference between a series circuit and a parallel circuit.

   A series circuit is where the current follows one path through each load (device). A parallel circuit is where current can flow through two or more alternate paths.

4. What did you observe about the brightness of the light each time you added another light bulb?

   Each time another light bulb was added, the light bulb became dimmer.

5. What happens when one of the light bulbs is unscrewed?

   When one of the light bulbs is unscrewed, all the lights go out.

6. Do question 4 of Further Analysis.

   Appliances in houses are generally not wired in series because if one failed to work, then the rest would not work. This is inconvenient. The only appliance that is wired in series is the oven. The oven has two fuses and if one is blown, the oven will not work.

7. What are the two main principles of a series circuit?

   The two main principles of a series circuit are as follows:

   - *Each load is dependent on the other. If one fails, the others fail as well. (e.g., If one light bulb is unscrewed, they all will go out.)*

   - *Each load reduces the amount of current going to the other loads. (e.g., The brightness of the light bulbs dims each time that a new light bulb is added.)*

8. Describe any changes in the brightness of the lamps as you added more light bulbs to the circuit.

   The brightness of the bulb remained the same when more bulbs were added to the circuit.

9. What happens when one of the light bulbs is unscrewed?

   When one light bulb is unscrewed, the other bulbs remain on.

10. Complete question 3 of Further Analysis.

    Textbook question 3. (a):

    The battery would be drained faster with two lamps connected in parallel.

    Textbook question 3. (b):

    Each separate conductor takes an equal load. The two light bulbs in this configuration draw twice as much current from the source, as compared to a series circuit.

11. Complete question 4 of Further Analysis.

    If one light goes out in a parallel circuit, the rest will remain on. In a series circuit, all the light bulbs will go out if one light goes out.

12. What are the two main principles of a parallel circuit?

The two main principles of a parallel circuit are as follows:

- *There is more than one pathway for current to follow. Each load receives electricity independent of the other loads. If one fails, the others still work. (e.g., If you unscrew one light bulb, the rest continue to work.)*

- *Added loads (of the same voltage) do not increase the resistance of the circuit or reduce the current available for the other loads. (e.g., The light bulbs' brightness stays the same. This will drain the cells a lot faster.)*

13. Complete question 5 of Further Analysis.

Textbook question 5. (a):

The circuits in a house are wired in parallel.

Textbook question 5. (b):

If one light burns out, the rest of the lights stay on.

Section 4: Activity 2

The following materials are needed for this activity:

- two D-size cells in holder
- three blocks of wood (10 cm × 10 cm square) or empty margarine containers with lids. Screws can be placed into the lids of the closed containers. Thick pieces of cardboard may be used instead.
- eight 2 cm wood screws
- screwdriver
- five connecting wires with clips
- 10 cm of copper wire
- two push-button switches, or doorbell switches, or scissor switches
- aluminum foil pie plate
- scissors
- door bell or 3 V lamp in socket

1. What is the problem for this investigation?

   The problem can be stated as follows: How can a light be turned on from either of two different switches?

2. When the circuit is first completed, the bulb is ___*on*___ (on, off).

3. After connecting the switch as shown in diagram (b), the bulb is ___*off*___ (on, off).

4. After connecting the switch as shown in diagram (c), the bulb is ___*on*___ (on, off).

5. Explain why the light can be turned on or off with either of the two switches.

   The students should have a similar answer to the following: With the light off, you can complete the circuit to turn the light on from either switch. With the light on, you can turn the light off from either switch in the same manner.

6. Where in a home would you encounter such a wiring arrangement?

   You could find this type of wiring in a hallway, a staircase, or at either end of a large room.

7. What is the problem for this investigation?

   The problem can be stated as follows: How can a single circuit be built for use with a front and back doorbell?

8. What happens to the door bell in each of the following situations?

   a. Each button is pushed at different times.

      When each button is pushed at different times, the door bell will ring.

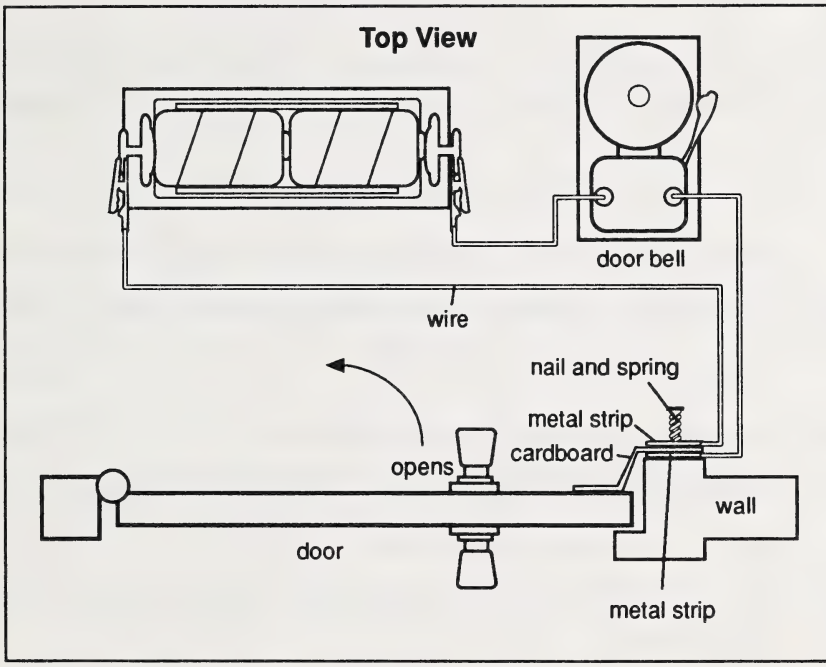
   b. The buttons are pushed at the same time.

      When the buttons are pushed at the same time, the door bell will ring.

9. What is the problem in this investigation?

   The problem can be stated as follows: How can a switch be used as a burglar alarm?

10. Draw a circuit for a burglar alarm that you could make for your bedroom door. Explain briefly how it would work.



When the door is opened the cardboard is removed. The two metal strips touch, completing the circuit and sounding the door bell (alarm).

Section 4: Activity 3

The following materials are needed for this activity.

- switch
- one 2 cm wood screw
- small flat-head wood screw
- screwdriver
- 1 m of 26 gauge insulated or coated copper wire
- six connecting wires
- one D-sized cell in holder
- two D-size cells in holder
- 1.5 V bulb in socket
- small block of wood (10 cm × 10 cm)
- strip tin (1 cm × 10 cm)
- 5 cm common nail

You may wish to have your students build the electromagnetic switch first to save time. You may have them try different materials for the switch to see which material is most strongly attracted to the electromagnet.

> **Caution:** When cutting a tin strip from a lid of a fruit or vegetable can, remember that the metal edges can be extremely sharp. Use a pair of tin snips to cut the metal to the required size.

1. What happened to the electromagnet and the light when the circuit was connected?

   The metal was attracted to the nail of the electromagnet, and the light went on.

2. What happened to the electromagnet and the light when the switch was closed?

   The metal was attracted to the nail of the electromagnet and the light went on.

3. What happened to the electromagnet and the light when the light was disconnected?

   The light did not go on, but the metal was still attracted to the nail of the electromagnet.

4. What made the metal strip touch the nail?

   The current flowing through the coil of wire sets up a magnetic field. The magnetic field attracts the piece of metal.

5. Is the light in the second circuit receiving its electricity from the same cell as the electromagnet?

   The light is receiving its electricity from a different cell than the electromagnet.

6. Give another example of where an electromagnetic switch or relay is used.

   Electromagnetic switches or relays are used in door bells, speakers, telephones, buzzers, and turn signals of cars.

Comment:

If you have access to any of these materials, it would be worthwhile to allow the students to examine a device to see how it works.

Section 4: Activity 4

The following materials are needed for this activity:

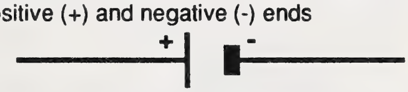
- three 3 V light bulbs in sockets
- two D-size cells in a holder
- two switches
- eight connecting wires
- buzzer or bell (optional)
- a piece of thin nichrome wire at least 36 cm long

Students must be able to draw the circuit symbols on page 205 of the textbook to accomplish this activity. You may encounter some problems when marking student circuits. Certain components can be in different spots. Series and parallel circuits can present individual problems. Turn to page 205 of the students' textbook for an explanation of the symbols used and diagrams of series and parallel circuits.

In diagrams (b) and (c) you can see that a series circuit is a chain of loads connected to a battery. The loads may be in any position on the circuit. Diagram (d) shows a parallel circuit. You can see that each load and switch is on a separate current path and can be activated or deactivated without affecting the other loads in the circuit.

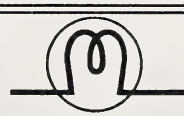
1. For each of the following items, draw the symbol that would be used to represent it.

cell - show the positive (+) and negative (-) ends



battery - show the positive (+) and negative (-) ends

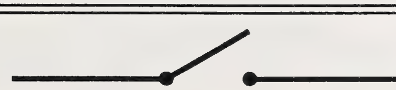
lamp

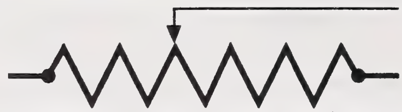
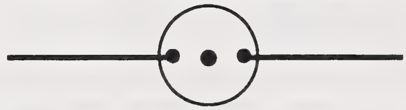


or

resistor

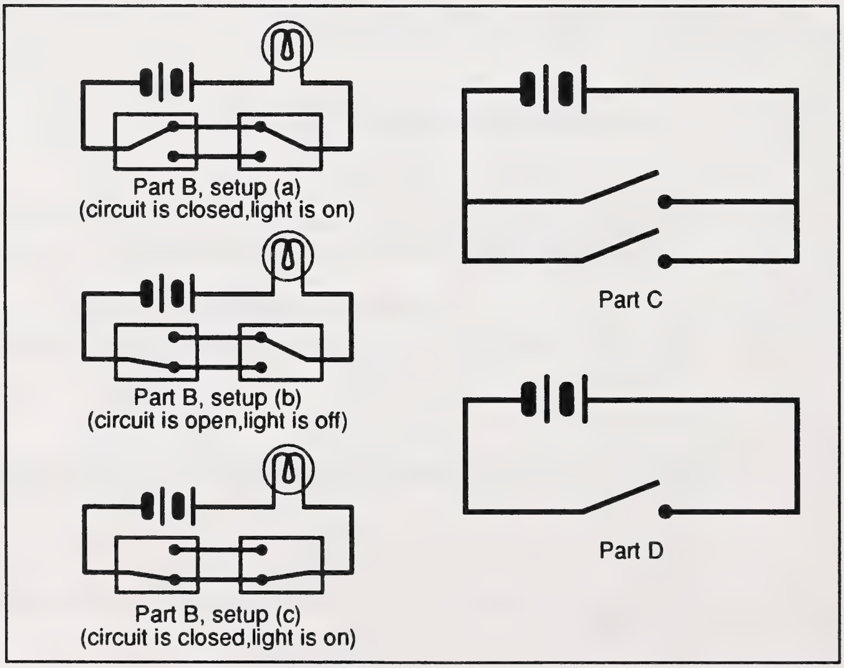
switch



galvanometer	
variable resistor	
motor	

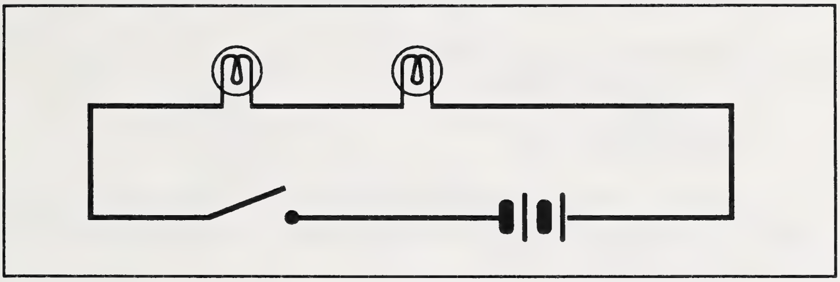
2. Go back to Activity 4-15 on pages 203 and 204. Use the proper symbols to redraw any two circuits from the activity. Create your own symbol for the door bell.

Note: Student symbols for the door bell may be different than what is shown here. Components may be placed in different orders.



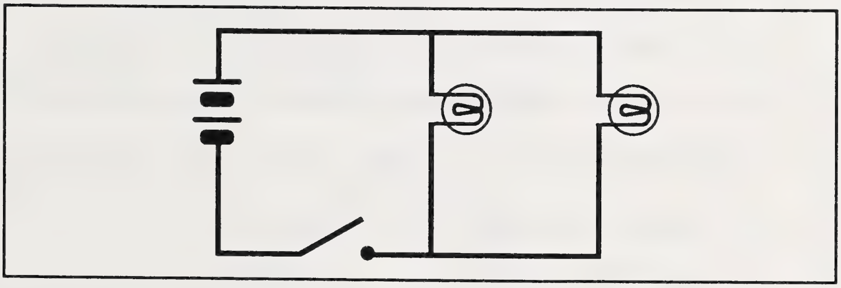
3. Draw a circuit diagram that shows two light bulbs hooked in series with a switch and a two-cell battery.

Components may be placed in a different order.



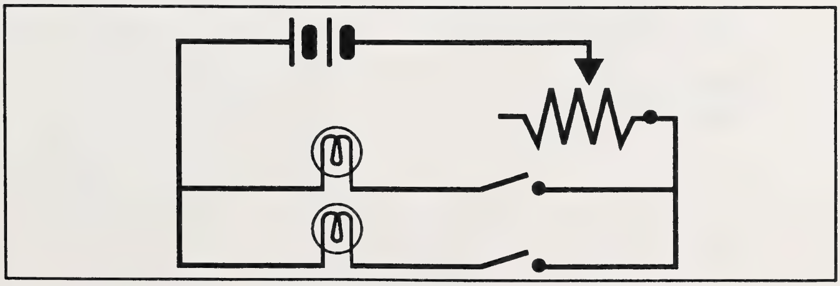
4. Draw a circuit diagram that shows two light bulbs hooked in parallel with one switch and a two-cell battery. The switch must turn both lights on and off at the same time.

Components may be placed in a different order.



5. Draw a circuit diagram that shows two light bulbs hooked with two switches, a variable resistor, and a two-cell battery. The switches must turn both lights on and off at different times. The variable resistor must vary the brightness of the light. (Remember the nichrome wire.)

Components may be placed in a different order.



Section 4: Follow-up Activities

Extra Help

The following materials are needed for this activity.

- three 3 V light bulbs in sockets
- two D-size cells in holder
- two switches
- eight connecting wires

This activity reinforces the basic differences between a series and parallel circuit. Note that the symbol for a light bulb is sometimes drawn as shown in the questions of Extra Help instead of as shown on page 205 of the textbook.

1. How does the number of cells affect the brightness of the light bulb?

   As you increase the number of cells, the light bulb becomes brighter.

2. How does the number of light bulbs affect the brightness of each individual light bulb?

   As you increase the amount of light bulbs, each bulb becomes dimmer.

3. How does the brightness of the light bulbs compare in the two circuits?

   The bulbs in the series circuit are dimmer than the ones in the parallel circuit.

4. What happens when one light bulb is disconnected from each circuit?

   When a bulb is disconnected from the series circuit, the other light bulbs will not work. When a bulb was disconnected from the parallel circuit, the other light bulbs will still work.

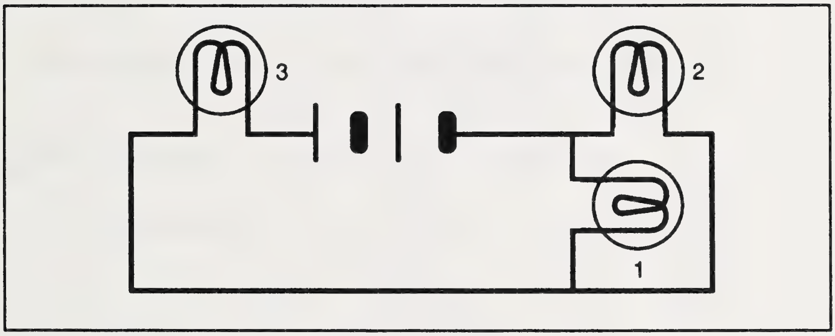
Enrichment

The following materials are needed for this activity:

- three 3 V light bulbs in sockets
- two D-size cells in holder
- two switches
- eight connecting wires

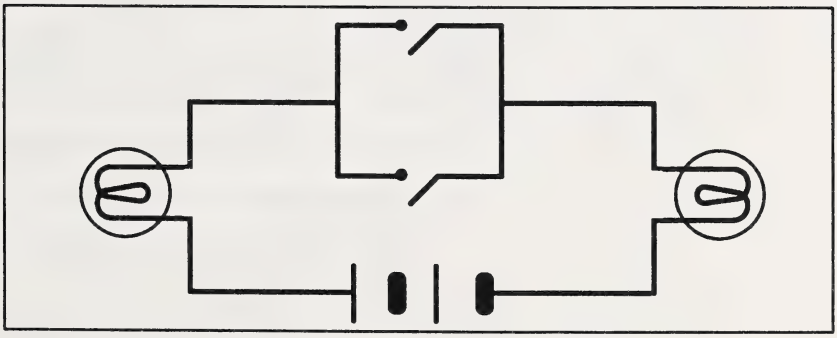
1. Design a circuit which has three light bulbs and meets the following conditions:

   - If bulb 1 is unscrewed, then bulbs 2 and 3 stay on.
   - If bulb 2 is unscrewed, then bulbs 1 and 3 stay on.
   - If bulb 3 is unscrewed, then bulbs 1 and 2 go out.



2. Design a circuit which has two light bulbs and two switches and meets the following conditions:

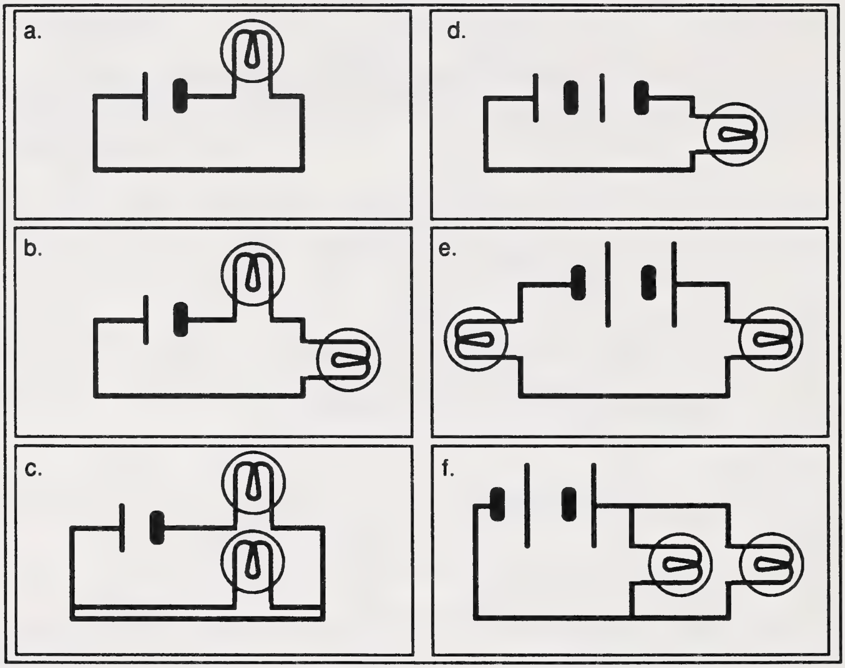
   - If both switches are open, both lights are off.
   - If either of the switches are closed, both lights come on.



Section 4 Assignment

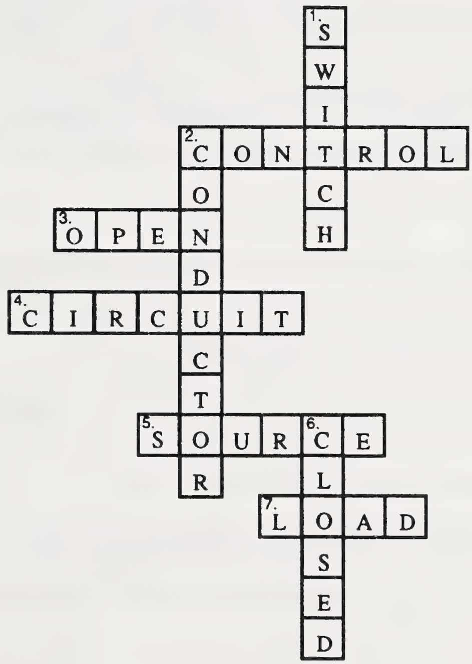
Marking Guide: Suggested values are given in brackets.

1. For each of the following circuits, indicate the degree of brightness that you would expect of the bulbs, as compared to the bulb in circuit a. Describe the brightness of the bulbs in each circuit as **same, brighter**, or **dimmer** as compared to the bulb in circuit a. (1 mark each)



circuit b: *dimmer*
circuit c: *same*
circuit d: *brighter*
circuit e: *same*
circuit f: *brighter*

2. Use the following clues to solve the crossword puzzle on the response page. (2 marks each – maximum of 14 marks)



3. Do question 4 of Checkpoint on page 217 of your textbook. (2 marks each)

Textbook question 4. (a):

Current will flow to the three bulbs, but not the bell.

Textbook question 4. (b):

No current will flow.

Textbook question 4. (c):

Current would only flow to bulb 1.

Section 5: Electricity in the Home

In this section students will see how electricity is safely brought into their homes and review their personal safety habits. Also in this section, students will be challenged to solve wiring problems using the skills and knowledge they have developed earlier in this module.

If possible, supply students with small electrical appliances that no longer work so that they can examine them. Check your local appliance repair shop as a possible supplier. Before giving them to students, cut off the electrical cords so they cannot be plugged in.

Section 5: Activity 1

1. What are the three wires that come into the house and what do they do?

   One of the three wires entering the house is grounded, or neutral. The other two wires, the "hot" or live wires, carry the electrical current.

2. When the wires first enter the house, they go through a *meter*.

   The purpose of this device is to keep track of *the amount of electricity used.*

3. Electricity next enters the *master panel (or service entrance panel)*. This device has two functions which are *to distribute the electricity and to hold the fuses or circuit breakers for safety.*

4. What is the main purpose of fuses and circuit breakers?

   Fuses and circuit breakers are used to limit the amount of electricity used by each circuit. If the amount of electricity used by each circuit was not limited, the wires could overheat and start a fire.

5. Describe how a fuse works.

   If too much electrical current passes through a fuse, a thin piece of metal melts and snaps, opening the circuit.

6. Describe how a circuit breaker works.

   A circuit breaker has a bimetallic switch in it. If too much electrical current passes through the strip, it heats up, bends, trips the switch, and opens the circuit.

7. If a 20 A fuse blows, should you replace it with a 30 A fuse? Explain your answer.

   You should never replace a 20 A fuse with a 30 A fuse in a circuit designed for a current limit of 20 A. The purpose of a fuse is to prevent fire. Certain circuits can only handle so much electrical current. If you replace this circuit with a higher fuse, the fuse will not protect the circuit from overloading or shorting out.

8. What should you do before you replace a blown fuse?

   Before replacing a blown fuse, find out why the fuse blew. If you do not know what the cause is, phone an electrician.

9. Write a safety rule for each of the pictures.

   There could be a variety of answers for each picture. What follows are a few key points for each picture.

   top left:

   Water is a good conductor, therefore, no electrical device should be used near water.

   top right:

   One circuit cannot handle a large load. If you try to overload the circuit, it could overheat and start a fire unless the fuse blows or a circuit breaker trips. You should never overload a circuit.

   bottom left:

   Fraying wires expose the bare wires. A person can get a serious shock. Also, if two wires touch, this would cause a short, and possibly a fire. Replace frayed cords right away.

   bottom right:

   High-voltage lines are fatal if you touch them. Be careful when moving tall objects around them. Also, never fly kites near high-voltage lines.

10. Why do you think there was no danger of getting a shock while doing the previous investigations?

    There was no danger of electrocution because only a few 1.5 V batteries were used at any one time. The voltage involved was always low.

11. What is the maximum number of D-size cells that can be connected in series without producing a potential danger for electric shock?

    The voltage produced by sixteen cells in series is 24 V (16×1.5 V). Seventeen cells in series produce about 26 V. A voltage over 25 V is potentially dangerous. Therefore, the maximum number of D-size cells that can be safely connected in series is sixteen.

Comment:

If the videotape *Volton* is available, it may be viewed to learn more about electrical hazards.

12. Use your knowledge of current flow to explain why a bird sitting on a 10 000 V power line does not get electrocuted.

    The bird does not provide a pathway for the electricity to get to the ground, so there is no current.

13. What would happen if the bird touched the transmission tower at the same time?

    The bird would now provide a pathway to the ground through the tower and it would be electrocuted.

Section 5: Activity 2

1. What are some devices that would use a bimetallic switch?

   There are a wide variety of devices which contain a bimetallic switch to measure temperature. Any of the following may be listed:

   - *oven thermostat*
   - *furnace thermostat*
   - *stove thermostat*
   - *refrigerator thermostat*
   - *car radiator thermostat*
   - *air conditioning thermostat*

2. Now it is your turn. Using the diagram of the hair dryer, explain how it works. You can use a real dryer to look at. Do not plug it in and do not disassemble it.

   Comment:

   This is meant to be a non-threatening question. Ask the student to keep it as simple as possible. Here is an example.

The hair dryer is comprised of two major subsystems controlled by a switch. When the switch is closed, electricity is supplied to these two subsystems. The first subsystem is the heating element. The element is made from thin wire that has a high resistance to the flow of electricity. This resistance changes electrical energy into heat energy. The second subsystem is the fan and motor. The fan's job is to push the hot air out the end of the dryer. The fan is turned by the motor. The motor converts electrical energy into mechanical energy.

Section 5: Activity 3

This is a very open-ended activity. Let the students try out their designs if the parts are available, and do not require a high voltage (above 12 V).

1. What are the two main subsystems in the mousetrap?

   The two subsystems are the electromagnetic trap for the mouse and the bell to let you know when you have trapped the mouse.

2. Since mice come out only at night, what could you do to the mousetrap so that it only works when it is dark out?

   You could add a third subsystem that uses a solar cell. As long as there is enough light, the solar cell will produce electricity. This electricity could be used to control the two subsystems. It could hold an electromagnet switch open on the bell so that it will not ring. It could also be used to power the electromagnet to keep the tin can suspended. This will not be effected by the switch on the pie plate.

3. What is your device going to do?

   Make sure that the students have a clear understanding and can describe the function of their devices and can describe the purpose of their devices.

4. Sketch at least two ideas of how your device is going to work.

   This is part of the planning stage of the technological problem-solving model. These need to be only rough sketches of some preliminary thoughts. No details are necessary.

5. Make a circuit diagram of your invention. Use standard electrical symbols wherever possible. Also write a brief explanation of how the device works.

   This is a very open-ended assignment. There is no real wrong answer here. What you are looking for is a good clear description of how the device works. Designs should use basic electrical concepts.

6. What could you do during construction to improve your design?

   Students should also be troubleshooting while they are building their devices. This might include changing the design to suit available materials and ease of construction.

7. If you had a working model of your invention, describe how you could evaluate your design.

   Answers will vary, but some method of testing should be suggested.

Section 5: Follow-up Activities

Extra Help

1. a device that safely distributes electricity throughout the house

   master panel

2. a device that measures the amount of electricity that enters a house

   meter

3. the wire that is electrically neutral

   ground

4. the wires that carry electricity or are "live"

   hot

5. a safety device that stops the flow of electricity when a thin piece of metal melts

   fuse

6. a safety device that stops the flow of electricity when a bimetallic switch heats up, bends, and turns a switch off

   breaker

U	M	X	M	L	F	Q	F	X	K	R
N	L	F	X	E	O	W	X	B	C	K
V	G	P	Y	N	X	D	D	B	Q	V
B	P	G	Z	A	N	K	K	S	Z	A
B	Z	B	O	P	N	V	Y	D	V	T
T	C	P	D	R	Y	E	F	O	Z	F
R	G	X	B	E	I	J	B	D	I	M
K	E	M	C	T	D	R	E	L	W	G
Q	E	T	V	S	E	N	S	F	J	S
I	H	B	E	A	Q	Q	U	T	H	Z
J	M	Z	K	M	N	J	F	O	M	C
J	K	E	U	O	E	G	T	V	R	Y
W	R	B	P	J	E	A	A	D	M	G

Enrichment

1. Pick one of the following devices. Use your knowledge of electricity to draw the device and explain how it works.

   Comment:

   Check to see that the drawing made by the student matches the explanation given by the student.

   a. airport metal detector: a walk-through device that will detect whether you are carrying any metal objects

      Airport metal detectors use the same concept as the magnet running through a coil of wire that you tested in Section 2. They use two sets of coils. The first coil of wire has a small current flowing through it to make both coils magnetic. When you walk through the detector with metal objects, the magnetic field is disturbed and a current is created in a second set of coils. This works the same as moving a magnet through a coil. When this happens the electrical current sets off the alarm.

   b. traffic lights that can detect when a car has arrived at the intersection

      Some traffic lights are able to sense when a car approaches an intersection. The detector uses the same concept of a magnet running through a coil of wire that you tested in Section 2. A coil of wire is placed in the road at the stop line of the intersection. This coil of wire has a small current flowing through it to make the coil magnetic. When a car approaches, the metal of the car disturbs the magnetic field and creates a current in the coil. There is a detector in the signal box. When this new current is detected, the signal lights will be switched.

2. Pick one of the following electrical appliances and see if you can figure out how it works.

kettle	record player
toaster oven	curling iron
thermostat	door bell
oven	

   This a very open-ended question. Use question 2 of Activity 2 as a reference.

Section 5 Assignment

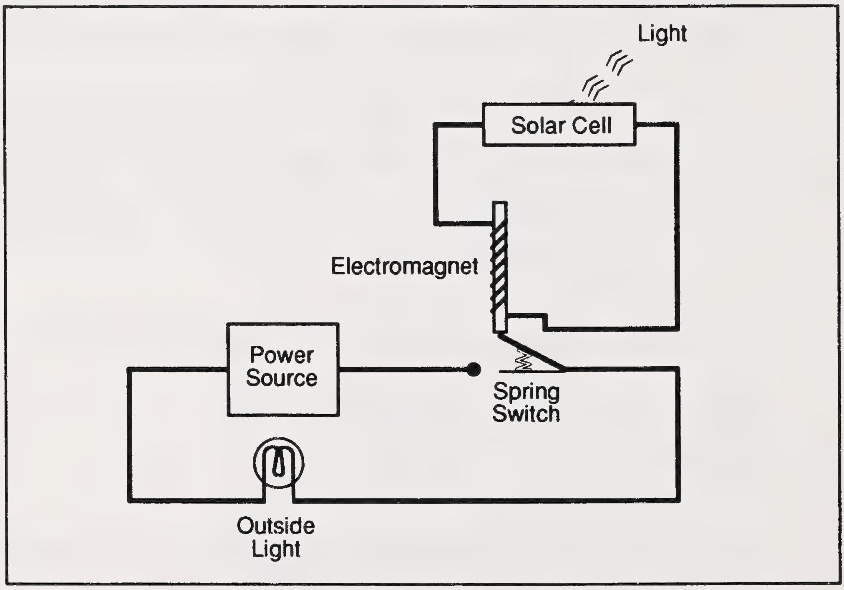
Marking Guide: Suggested values are given in brackets.

1. You have been put in charge of electrical safety in your area. Write a paragraph concerning safety in the home. (5 marks)

   You are looking for some common sense rules concerning the safe handling of electricity. Some examples follow:

   - *Check for buried cables before you dig.*
   - *Avoid high-voltage lines when moving tall objects.*
   - *Do not use electrical equipment with a frayed cord.*
   - *Do not use electrical equipment around water.*
   - *Do not repair electrical equipment while it is plugged in.*

2. Explain how the following automatic lighting system works: When it starts to get dark, your outside lights come on; when it becomes light enough in the morning, the lights go off. You must draw the circuit using proper symbols and write out a brief explanation of the circuit. (This question can be marked out of a total of 5 marks. 1 mark for each component that is operational)



As long as there is light, the solar cell will produce electrical current. The electromagnet keeps the switch open until there is no current. At dusk, when the sunlight becomes dim, the solar cell stops producing current and the switch closes turning of the light. In the morning, when the solar cell starts to produce current again, the electromagnet opens the spring switch and the light is turned off.

Answers will vary, but the basic components shown above should appear in students' responses.

Final Module Assignment

Marking Guide: Suggested values are given in brackets.

1. Complete question 1 of Unit Review on page 218 of your textbook. (1 mark each)

   Textbook question 1. (a):

   Static electricity stays where it is as a charge on an object. Current electricity flows through a conductor.

   Textbook question 1. (b):

   A single cell converts chemical energy to electricity. A battery is a group of cells joined together.

   Textbook question 1. (c):

   Electrodes are the terminals of a cell or battery. They receive or release current. An electrolyte is the solution that surrounds the electrodes.

   Textbook question 1. (d):

   A generator converts mechanical energy into electricity. A motor does the reverse.

   Textbook question 1. (e):

   An open circuit does not allow the flow of electrons through a conductor, due to a break in the path. A closed circuit allows electrons to flow by providing a complete path.

   Textbook question 1. (f):

   Parallel circuits have more than one path for electricity to flow through. Series circuits provide only one path for electron flow.

   Textbook question 1. (g):

   A fuse can only be used once. A breaker can be reset and used again.

2. Complete question 4 of Unit Review on page 218 of your textbook. (2 marks)

   Cell (d) would be the most effective because it has the strongest electrolyte and two different electrodes.

3. Complete question 5 of Unit Review on page 218 of your textbook. (1 mark)

   If a metal with higher resistance than nichrome wire is used, there would be less heat produced in the toaster since the current would be reduced. This is a question that requires more thought and an understanding of electrical formulas which the students have not yet covered; give credit for plausible reasons even if students predict that more heat would be produced due to the higher resistance of the wire.

4. Complete question 6 of Unit Review on page 218 of your textbook.

   Textbook question 6. (a): (2 marks)

   If more turns are added to the generator, then the light bulb will be brighter.

   Textbook question 6. (b): (2 marks)

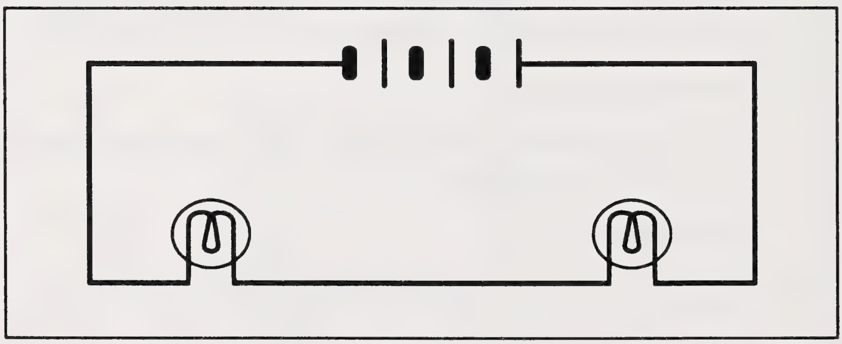
   If the generator shaft is turned slower, the light bulb will be dimmer.

   Textbook question 6. (c): (2 marks)

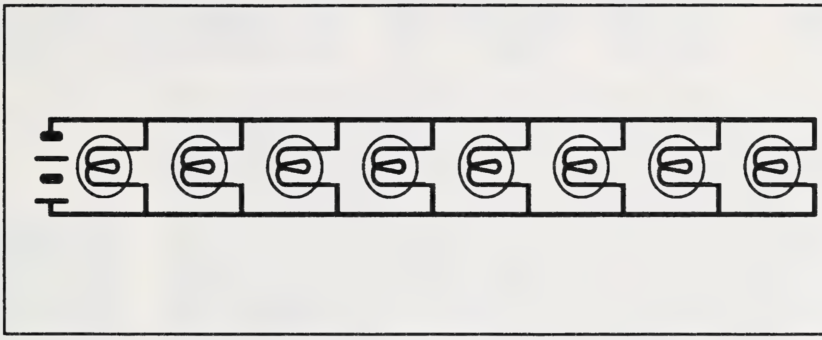
   If a stronger magnet is used in the generator, the light bulb will be brighter.

5. Complete question 10 of Unit Review on page 219 of your textbook.

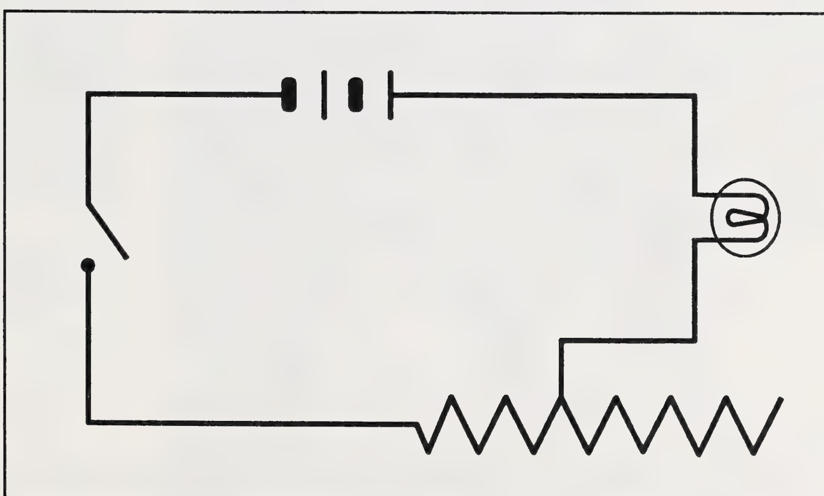
   Textbook question 10. (a): (3 marks)



Textbook question 10. (b): (3 marks)

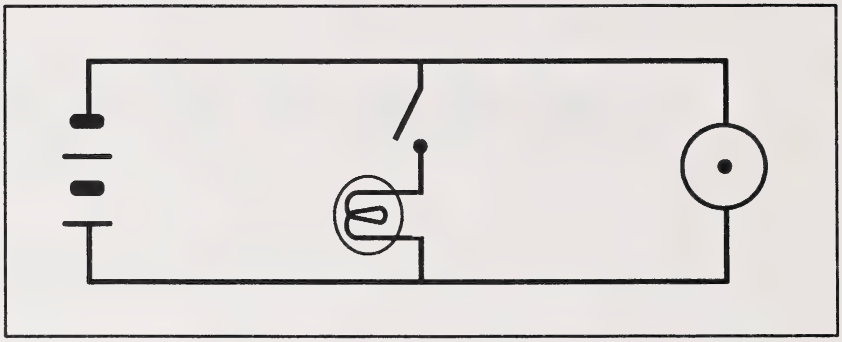


6. Draw a diagram of a circuit that has two cells, a switch, a variable resistor, and a lamp. The switch opens and closes the circuit and the variable resistor controls the brightness of the light bulb. (4 marks)

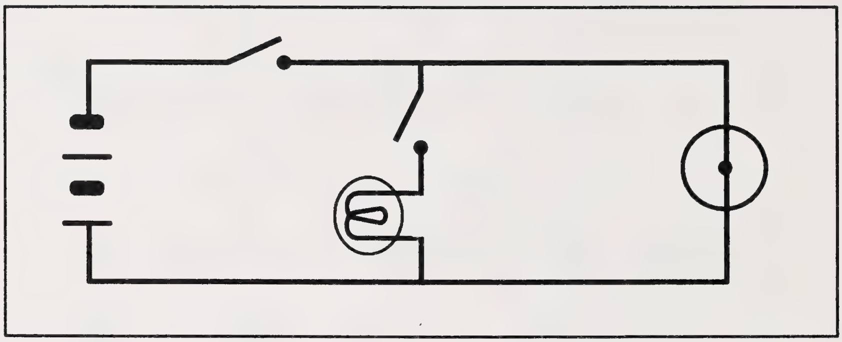


7. Complete question 11 of Unit Review on page 219 of your textbook.

   Textbook question 11. (a): (1 mark)



   Textbook question 11. (b): (1 mark)



8. Explain how a fuse works. (2 marks)

   When too much electricity flows through a circuit, the thin metal strip melts, causing the circuit to open.

SCIENCE 9

Module 5

Diversity of Living Things

LEARNING FACILITATOR'S MANUAL

Distance Learning

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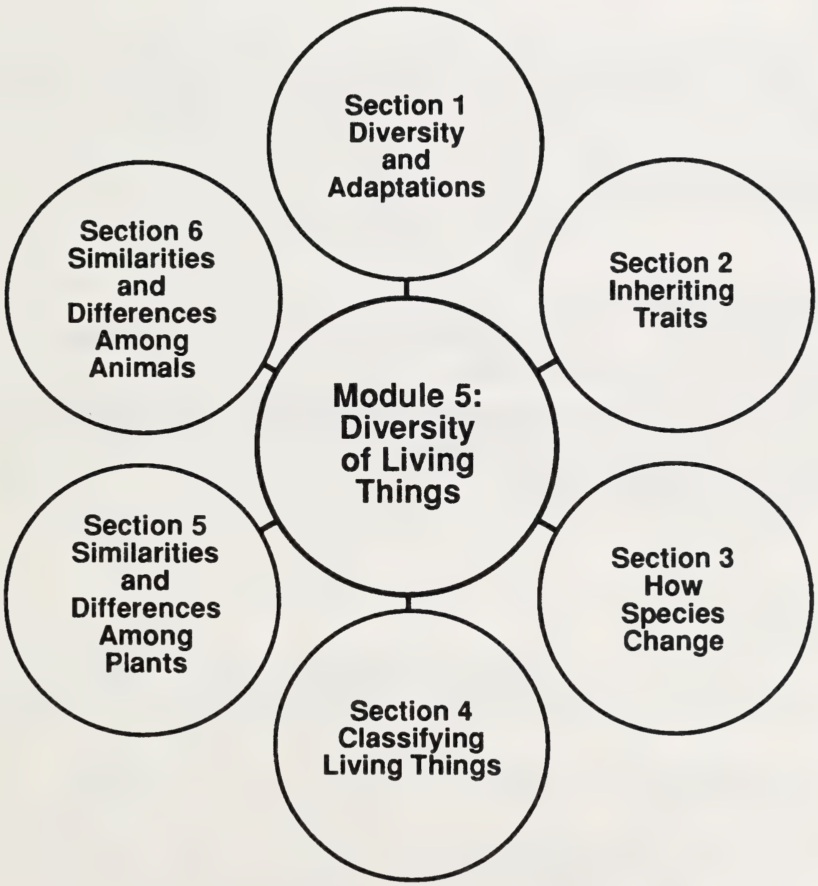
EDUCATION

Module 5 – Diversity of Living Things: Overview

The major emphasis of this module is the nature of science.

In this module students will examine the characteristics of living things. They will see how each organism is suited to a different part of the environment and how each organism contributes to the diversity of life on Earth. They will discover how species characteristics are passed on to each new generation and how variation, selection, and breeding help a species adapt. Lastly, they will learn how living things are classified based on similarities and differences.



Classroom Opener

Read the introduction to Unit 5 on page 220 of *Science Directions 9*.

Use a copy of *Guinness Book of Records* as a reference and ask students to guess the largest, smallest, most poisonous, or longest living organisms.

Examine the pictures on page 221 and discuss how each organism is adapted to its environment.

Media

Video cassettes may be available from your regional media centre. If not, contact the ACCESS Network for more information. The following videos have been included in a pathway in this module:

- *Adaptations of Animals*
- *Adaptations of Plants*

Materials and Equipment

The following materials will be needed:

- resource books which have information about plants and animals (encyclopedia and dictionary)
- field guide to plants in your area (optional)
- hand lens or magnifying glass
- measuring tape

Evaluation

The mark in this module will be determined by students' work in the Assignment Booklet. Students must complete all assignments. In this module students are expected to complete six section assignments.

The assignment breakdown is as follows:

Section 1 Assignment	**15%**
Section 2 Assignment	**15%**
Section 3 Assignment	**10%**
Section 4 Assignment	**20%**
Section 5 Assignment	**20%**
Section 6 Assignment	**20%**
TOTAL	**100%**

Section 1: Diversity and Adaptations

This section is centred around the adaptations of plants and animals. Adaptations are important features that enable living things to survive.

Encourage students to use available resources such as magazines, reference books, newspapers, television documentaries, and professionals to promote an appreciation of the wide variety of living things. In the activities, students should investigate wild plants and animals.

Section 1: Activity 1

1. Fill in the chart.

   Students should follow the directions as instructed. To get some information about adaptations, they may read pages 222-224 of the textbook or view the videotapes ***Adaptations of Animals*** *and* ***Adaptations of Plants.*** *You may help students identify the functions of the structures listed in the chart. Look for details that relate to the function of the structure and possible environments that match the organism. Sample responses may be as follows:*

Structure	Function of the Structure	Possible Environment
hummingbird beak	collects nectar from deep inside flowers	grassland forest
webbed feet on a duck	*swimming, prevents sinking into mud*	*fresh or salt water, ponds, rivers, lakes, marshes, ocean*
thorns on a rose plant	*protection from animals*	*forest, prairie, alpine*
wings on a duck	*movement, protection*	*marsh, prairie, pond, lake, river*

2. What is the problem in this investigation?

   The problem may be stated as follows: How do various structures help organisms survive?

3. The name of your choice is ________________.

   Responses will vary. Students may choose any non-domestic organism.

4. Describe the environment your organism lives in.

   Responses will vary, depending upon the organism. Look for a corresponding and suitable environment. For example, the environment for a mallard duck would be a water or shore environment.

5. Draw a sketch or glue a picture of this organism in the middle of the space provided. Allow as much space as possible around your picture for writing comments.

   Students may sketch or paste a picture of the organism of choice in the middle of the sheet. The organism should not be a domesticated plant or animal. Make sure that the illustration does not take up the entire space.

6. Do steps 2, 3, and 4 of the procedure outlined in the textbook. Record the information about your organism around the sketch or picture. The example in the textbook will show you what to do.

   Responses will vary. Check for completeness. Functions must be labelled and the adaptations must be described. The example in the textbook on page 255 should help you spot the details. The adaptations described should include structures for locomotion, obtaining food, body covering for protection, and defences against enemies. The diagram should be more elaborate if students have resources to research the details about the structures and their functions.

7. How many different functions did you label?

   The number of functions will vary. For example, the student may have listed five different functions about an organism, including locomotion, protection, obtaining food, eating food, etc...

Comment:

The following textbook questions are from page 225 of *Science Directions 9*.

8. Answer question 2 of Analysis on page 225 of your textbook.

   Textbook question 2. (a):

   Answers will vary. One example might be the alligator and the carp (fish).

Textbook question 2. (b):

Answers will vary. One example might be the frog and the duck. Both have webbed feet for swimming.

9. Answer question 3 of Analysis.

Textbook question 3. (a):

Answers will vary. One example might be a porcupine with quills and a rabbit with speed and a white coat in winter.

Textbook question 3. (b):

Answers will vary. One example might be the porcupine and the sea urchin. Both have quills, but they live in very different environments.

Section 1: Activity 2

1. List one similarity and two differences between the leaves.

Any one of the following similarities may be listed: all have veins and all have similar green colour. Any two of the following differences may be listed: different shapes, clusters or single attachment to stem, sizes, number of leaflets attached to one main stalk.

2. Describe how leaf shapes may be related to survival in different climates.

In cooler or dry climates, leaves are smaller and thinner to prevent water loss. In warm and humid climates, leaves are larger to absorb more sunlight. The shape and size of a leaf are therefore related to their survival.

3. Define the term *species*. Make sure that your definition includes the two aspects that are mentioned in the text.

Organisms with the same set of adaptations form a species. Different species might only differ by one feature. Reproduction only occurs within their own species.

4. List the characteristics that would help you tell the difference between these butterflies.

Differences would include wing shapes, wing patterns and colours, as well as body sizes and shapes.

5. The Monarch and Viceroy butterflies are an example of mimicry. Research these insects and describe how mimicry helps the Viceroy butterfly to survive.

   The students should observe that the wing patterns on these butterflies are not too different from each other. On the left is a Monarch butterfly. It has a distinct wing pattern. It also is bitter tasting to birds, thus protecting it from predators. On the right is the Viceroy butterfly which has a wing pattern that resembles that of the Monarch butterfly. It is a very sweet tasting butterfly. Predators, such as birds, do not eat Viceroy butterflies because they resemble the Monarch, which the birds have learned do not taste good.

6. Look at the picture below and describe the mutual relationship between these two organisms.

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   The plant provides the nectar for the honeybee and, in turn, the honeybee helps the plant in pollination. Honeybees and certain flowers represent mutualism.

Section 1: Activity 3

Students may do either Part A or Part B.

Comment:

Part A involves going outside and using a field guide in a natural area that has a variety of plants. The investigation can be done by individual students or by students working in groups. Caution students not to remove any plants from the study area unless they have your permission. If students cannot study plants outdoors, they may do Part B. Part B involves observing different species of animals in an illustration.

1. What is the problem in this investigation?

   The problem may be stated as follows: What differences and similarities are there among the plants and animals in your area?

2. Do step 3 of the procedure.

   Responses will vary, depending on the area. It could be a sunny or shady area, damp or dry, exposed or sheltered. Example: The area is sunny, dry, and exposed and is located on the prairies.

3. Use the following table to do step 4 of the procedure. Observe as many different types of plants as you can. Fill in the table as you observe the area.

   A complete table may contain a few or many different types of plants, depending upon the study area. Check the table for a complete list of features and descriptions. Sample answer:

Species Name	**Approx. Count**	**Brush, Tree, or Small Plant**	**Upright, Climbing, or Crawling**	**Approx. Height (cm or m)**	**Shape of Leaves**	**Special Adaptive Characteristics (e.g., Type of Flower or Type of Seed)**
dandelion	*15*	*flowering plant*	*upright*	*15 cm*	*long, narrow, notched edges*	*bright yellow flowers, long roots*

4. Which structures are most common in the plants you described?

   Responses will vary. Many structures may be common, such as the shape of leaves, roots, and the size of branches. The most common structures will be pointed leaves on the trees and long blade leaves on the grasslike plants. Students may mention that the trees are all tall.

Comment:

For questions 5 and 6, the textbook questions come from page 229 of *Science Directions 9*.

5. Answer question 2 of Analysis on page 229 of your textbook.

   Responses will vary, depending upon the plants. Look for the naming of similar and different structures in the plants that were studied.

   Textbook question 2. (a):

   An example of similar structures would be a dandelion plant and a wild rose plant. Both have leaves, each has a flower, and each has roots.

Textbook question 2. (b):

Some examples of differences would be that the rose is a taller plant, the dandelion has long narrow leaves, the rose plant has rounded leaves, the rose flower is pink, the dandelion flower is yellow, etc...

6. Answer question 3 of Analysis.

   Responses will vary. Any adaptation that is described should have an explanation of how it helps the plant survive or reproduce. For example, the rose plant has tiny thorns that protect it from animals, the poplar tree has large leaves to absorb more sunlight, and the stink weed has an unpleasant smell to keep consumers away.

7. Describe the area or environment shown in the illustration.

   The environment they share is a marsh or wetland. It has a lot of shallow water filled in with plants.

8. Use the preceding illustration to answer this question. Complete the following table by identifying and recording five types of animals in the first column. Count the number of each type of organism that you identified. Record the total in the second column of the table. In the third column on the table, briefly describe the shape, size, body covering, appendages, and other special features of the species that you observe.

   Sample answers are shown in the table. The table is continued on the following page.

Observations

Identifying Feature or Name	Total Number	Description (Shape, Size, Body Covering, Special Features)
blackbirds	*8*	*wings for flight and movement, feathers for warmth, beak for feeding*
spider	*1*	*eight legs, spins a web to trap food*
heron	*1*	*long neck and beak for feeding, long legs for wading, wings for migration, feathers for warmth*
fish	*2*	*fins for swimming, gills for breathing in water*

Observations

Identifying Feature or Name	Total Number	Description (Shape, Size, Body Covering, Special Features)
ducks	*6*	*webbed feet for swimming, special beak for bottom feeding, feathers for warmth and protection from water*
frogs	*2*	*skin colour for camouflage, webbed feet for swimming, and strong legs for jumping*
ladybug	*1*	*hard outer cover for protection, wings for movement, special mouth parts for feeding*

9. Name a structure that the blackbirds and frogs have in common.

   Responses will vary. Many structures of the frog and blackbird are common to both. For example, feet for support, eyes to see, mouth to take in food, organ to produce sound, lungs to breathe, legs for locomotion, etc...

10. Name a structure which is different in blackbirds and frogs.

    Responses will vary. Many structures are different between the frog and the blackbird. For example, the blackbird has a beak, while the frog does not; blackbirds fly and frogs do not; blackbirds have grasping feet and frogs have webbed feet, etc...

11. Select one of the animals and describe how a specific structure helps the animal survive.

    Responses will vary. All the structures of adaptation are useful for the animal to survive. For example, animals have adaptations such as a mouth to feed. Without food they would die. They also may have feet or wings for locomotion and protective coverings such as feathers or hair for protection from the weather, etc...

Section 1: Activity 4

1. Fill in the following chart to summarize the main points you have just read in the textbook.

Variation	Brief Description	Possible Adaptive Value	Example of Species
Metamorphosis	During the life cycle, the organism changes in appearance. New structures may appear (e.g., wings). Old structures may disappear (e.g., legs, gills).	There is less competition for food between organisms of the same species.	Butterfly Frog Beetle
Sexual Dimorphism	*The males and females look very different (e.g., in colour).*	*This may help to attract a mate or serve to camouflage from predators.*	Peacock Paper Nautilus
Polymorphism	*Each form has adaptations for a particular function.*	*This helps to distribute the many jobs in order for a colony to survive.*	*Termites* *Ants* *Bees*

Students should be encouraged to find other examples of species by using reference books.

2. Describe two examples of how the young members of a species may differ from the adult members. Hypothesize how this may be of adaptive value.

   Six examples are stated in the textbook. Students may state two or three of these examples.

   Example: Fawns are spotted or striped, whereas adult deer are solid in colour. This may provide camouflage for the fawn, which cannot run quickly from predators. Young seals are white so that they blend into the snow (camouflage) until they are capable of swimming away from predators.

3. Describe two examples of variations that are related to the changing seasons and hypothesize how they are an adaptation for survival.

   Students may use the examples from the textbook or may use other examples.

   Example: The weasel and arctic hare are white in the winter to blend into the snow and allude predators. They have brown colouring in the summer so that they blend in with the summer foliage.

4. Match the Greek parts of words in Column A to their meaning in Column B.

Column A	**Column B**
___*c*___ morph	a. many
___*d*___ meta	b. two
___*b*___ di	c. form
___*a*___ poly	d. change

5. Define the following terms in your own words.

metamorphosis: *the extreme changes that occur in the life cycles of some animals*

sexual dimorphism: *the presence of males and females with different characteristics in a species*

polymorphism: *many forms of the organism are seen in the same species*

Section 1: Follow-up Activities

Extra Help

1. Use the following observation chart to help you summarize how each organism on page 221 moves, protects itself, and obtains food. List the special structures it possesses and describe the environment it may live in.

Organism's Name	How Does it Move?	How Does it Protect Itself?	How Does it Obtain Food?	Environment	Special Features
water lily	*floats*	*flat leaves*	*produces own*	*pond*	*large flowers and leaves*
monkey	*arms, legs, tail*	*climbs*	*gathering*	*rain forest*	*warm blooded*
sea sponge	*does not move*	*camouflage*	*from continual flow of water*	*ocean*	*many pores, flagella*
iguana	*legs and tail*	*camouflage*	*hunting insects with tongue*	*dry, desert*	*cold blooded*

Organism's Name	How Does it Move?	How Does it Protect Itself?	How Does it Obtain Food?	Environment	Special Features
anemone	*depends on movement in water*	*some varieties are poisonous*	*strains water*	*ocean*	*tentacles*
penguin	*flippers, webbed feet*	*camouflage, swimming*	*catching fish with beak*	*Antarctic polar seas*	*flightless bird*
skate	*flat fins, long tail*	*camouflage, movement*	*bottom feeder*	*ocean*	*flat*
wasp	*wings and legs*	*stinger, flight*	*tongue*	*forest, meadow, grassland*	*six legs, compound eyes*

Enrichment

1. Examine the life cycle and describe the adaptations that the frog has for each stage in its life cycle. In your description include a variety of adaptations that the frog uses to survive at each stage.

   The description of the adaptations in each stage of the life cycle might include the following:

   - *egg: Hundreds of eggs in a bunch are surrounded by a jelly-like substance near the top of the water for protection and to absorb heat from the sun.*

   - *tadpole: Once hatched, the tadpole swims through the water with the aid of its tail. It eats algae and protists with its mouth. The gills enable it live in the water. As it matures and grows, the tadpole develops hind legs to swim faster for protection and to capture food. As front legs develop, the tadpole also develops internal lungs that will enable it to emerge onto land near water.*

   - *young frog: With lungs, the young frog can breathe air and manage life activities on land. Its mouth and quick tongue are adapted to capture insects. The short tail is absorbed and the frog uses its legs and webbed feet to move on land and through water.*

   - *adult frog: Each structure of the adult frog is strongly developed for protection, movement, and food gathering. To ensure survival, internal organs for reproduction mature and the life cycle continues.*

Section 1 Assignment

Marking Guide: Suggested values are given in brackets.

Comment:

For question 1, the textbook question comes from page 241 in *Science Directions 9.*

1. Answer question 2 of Checkpoint on page 241. (6 marks: 1 mark for each organism)

   The responses to the question should be specific in each case.

   snail shell: *for protection from predators*

   kangaroo leg: *for quick movement, jumping*

   water lily leaf: *large surface area exposed to the sun for food production*

   shark tail: *for movement through water and for stability*

   crab claw: *for gathering food and protection*

   pine tree cone: *production of reproductive cells and protection of seeds*

2. Every living thing has certain structures and behaviours that help it adapt to the environment in which it lives.

   a. Describe the environment in which a fish must live. (3 marks)

      Some fish live in fresh water, while others live in salt water. The water must contain an adequate supply of oxygen and food.

   b. How is the fish adapted for survival in its environment? (3 marks)

      A fish uses gills to obtain oxygen from the water. Its mouth is adapted to efficiently take in food from the water. Its fins and tail are essential for movement. A fish has a protective covering to keep water out and internal structures in place. Depending on the fish, some sort of protection from predators should be mentioned.

3. Explain how migration is used by some animals as an adaptation for survival. (3 marks)

   Seasonal migration by some animals allows them to find adequate food supplies. If these animals did not migrate to an adequate food source, they would become extinct, even if they were able to withstand the changing climate.

Section 2: Inheriting Traits

In this section the students will review sexual and asexual reproduction of living things, and will be introduced to the study of genetics. You can expect students to be very interested in their own traits and the activities will generate many questions. As you answer the questions, remember that characteristics or traits appear in many possible combinations. The rules of genetics are complex and all occurrences or non-occurrences of specific traits cannot be explained at this level. The sudden appearance or disappearance of certain traits is explained using the concept of recessive genes. The highlight of the section is artificial selection. Artificial selection is a process to cross desired characteristics of plants or animals to increase food production, appearance, or other qualities. Students should be encouraged to question the process and develop personal attitudes.

Section 2: Activity 1

In this activity students should include ten or more people in their survey. No more than three people can be from one family.

1. What is the problem in this investigation?

   The problem may be stated as follows: Are some forms of traits more common than others?

2. Place a check mark in the appropriate column beside the form of the trait that best describes you.

   Comment:

   Students will first look for the traits that they possess. They are to place their responses in the third column of the table provided. Every family member may have different traits and many trait combinations are possible. Students may question where they received their traits. If they do not match up with the parents, remind them traits may skip generations and suddenly appear.

   The table on the following page represents a survey of ten people. Sample data is given.

Occurrence of Traits in a Group

Trait	Form of the Trait	My Traits (✓)	Group Traits (Place ✓ Beside Each Visible Form)										Percentage of Group with Each Form of the Trait
tongue roller	non-roller		✓			✓			✓				*30*
	roller	✓		✓	✓		✓	✓		✓	✓		*70*
ear lobe attachment	free	✓	✓		✓	✓		✓		✓			*60*
	attached			✓			✓		✓		✓		*40*
thumb shape	curved	✓	✓	✓		✓	✓		✓	✓	✓		*80*
	straight				✓			✓					*20*
number of wrist cords	two		✓	✓			✓	✓		✓			*50*
	three	✓			✓	✓			✓		✓		*50*
hairline shape	straight	✓	✓			✓			✓	✓	✓		*60*
	widow's peak			✓	✓		✓	✓					*40*
		Names	*Greg*	*Nichole*	*Sajila*	*Rod*	*Jason*	*Michael*	*Jessica*	*Sabine*	*Nancy*		

3. Survey your group or class for their traits. Question one person at a time. Record the information in the preceding table in the section for group traits. Place a check mark in the appropriate column across from the form of the trait that best describes each individual in the group. If a larger group (more than ten people) is surveyed, you may create a separate table to record your information.

   See sample data.

4. Count the total number of check marks for each trait, including your own. Then calculate the percentage of each trait in your group. Record the information in the last column of the table.

   See sample data.

   Comment:

   Students should include themselves as part of the survey group. Calculating percentages can be difficult for some students. Use the example in the student booklet for help. Students may use a calculator.

5. Examine the percentages of people in your group that have each of the ten different forms of the traits. Order the traits from most common to least common.

Trait	%	Trait	%
1. *curved thumb*	*80*	6. *three wrist cords*	*50*
2. *tongue roller*	*70*	7. *attached ear lobe*	*40*
3. *free ear lobe*	*60*	8. *widow's peak*	*40*
4. *straight hairline*	*60*	9. *tongue non-roller*	*30*
5. *two wrist cords*	*50*	10. *straight thumb*	*20*

Comment:

These results do not represent the statistical norm for a large group.

6. How many people that were surveyed have exactly the same combination of traits?

Very few people carry exactly the same combination of traits. Depending upon the survey group and the number of people surveyed, there will be a variety of combinations. The probability of inheriting exactly the same traits is very rare.

7. Write a generalization about the variation of humans that you observed in this survey of traits.

In general, there are a wide variety of traits in humans. People may look alike, but they may have many traits that are not alike. There are many combinations of traits possible in humans, making each person unique.

8. Do questions 3, 4, and 5 of Further Analysis on page 236 of your textbook.

Textbook question 3:

Answers will vary. A few examples are eye colour, hair colour, finger shapes, nose shapes, etc...

Textbook question 4:

Answers will vary. A few examples are size of feet, shape of body, weight, etc...

Textbook question 5:

All the traits from parent to offspring would be the same; therefore, it would be difficult to tell one person apart from another. For example, each person would have the same eye colour, shape, height, etc...

9. What is the science of heredity called?

   The science of heredity is called genetics.

Section 2: Activity 2

1. Describe two examples of asexual reproduction.

   Examples of asexual reproduction may include such things as bulbs, runners, and shoots in plants, or budding and cell division in animals.

2. Fill in the following blanks.

   Sexual reproduction requires the union of two sex cells or ___*gametes*___. The male sex cell is the ___*sperm*___ and the female sex cell is the ___*egg*___. They join together during fertilization to form a ___*zygote*___.

3. What colour will the offspring be?

   The offspring will be black since the gene for the colour black is dominant.

4. Why is the inheritance of genes through sexual reproduction a benefit to the overall survival of a species?

   Inheritance of genes through sexual reproduction is a benefit because a wider variety of traits can be combined to provide a source of variations in offspring. Variations in a population may provide helpful adaptations in a changing environment.

Section 2: Activity 3

Comment:

For questions 1 to 3, the textbook questions come from page 240 in *Science Directions 9*.

1. Do question 1 of the activity.

   Textbook question 1:

   Responses will vary in each case. A few examples follow:

   a. race horses: *colour, size of legs, height*

   b. apple trees: *height of tree, variety of apples*

   c. turkeys: *colour, weight gain*

   d. hunting dogs: *good runners, obedience, good sense of smell*

   e. guard dogs: *vicious, loud bark, good sense of hearing*

   f. roses: *colour, scent, hardy over-wintering*

   g. beef cattle: *rapid weight gain, meat tenderness and flavour*

   h. dairy cattle: *milk production*

   i. rodeo cattle: *lively disposition and aggressive nature*

   j. sheep: *quality of wool, size, multiple offspring, quality of meat*

   k. corn: *quality, resistance to disease, length of growing season*

   l. wheat: *resistant to disease, yield, length of growing season*

2. Answer question 2 of the activity.

   This question is an opinion statement that should be supported with an explanation of why some of these organisms can or cannot survive in the wild. Most of the organisms should be able to survive without the aid of humans as long as there are water and food supplies.

3. Answer question 3 of the activity.

   Answers may vary. Sample answers follow.

   brussel sprouts: to develop many buds on the stem of the plant

   red cabbage: red colour and leaves that will fold into a sphere

   kohlrabi: a storage stem to store food near the bottom of the plant

   cauliflower: enlarged flower structure that stores food at the top of the plant

Section 2: Follow-up Activities

Extra Help

1. List the traits that you would like to see in an improved dairy herd.

   Students may suggest improvements such as high milk production, hardiness, resistance to disease, well-developed udders for easy milking, and a high quality of milk.

2. Could you tell if a newborn female offspring has the desired traits? Explain.

   No, you could not tell if an offspring will develop traits such as high milk production until the cow actually produces milk. The male offspring would never show this characteristic, although it may appear in cows of future generations.

3. What is the next step in your breeding program after you have identified the most productive offspring?

   The next step is to use the best cattle as breeding stock for a new generation.

4. As a result of artificial selection, how should the milk production of the dairy be at this point?

   The dairy would probably have a high quantity of milk produced as a result of this selective breeding program. Some other undesirable traits may be associated with the high milk production of the herd, such as short life span of the animal.

5. As a dairy farmer, would you agree with this practice of selective breeding? Why or why not?

Students should be able to support their opinion with a logical and clear statement. Example: Yes, I agree with selective breeding because I will get more income from higher milk production from fewer cows. This means a saving of labour, feed costs, and equipment costs. The consumer is also guaranteed a better product.

Section 2: Enrichment

1. Name the traits described in the previous paragraph.

The traits described in the preceding paragraph are the colour of fur and the length of ears on the rabbits.

2. Describe how you would develop a pure breed of rabbits that would be white in colour and have long ears.

Each student's approach may be different; however, the main points should be contained in the description. First, there should be a selection of breeding stock with the desired characteristics. Breeding should be arranged between pairs with desired characteristics over several breeding cycles. Eventually all the offspring will have white fur and long ears.

3. Would new varieties of living things be developed if humans were not present to act as the selector? Why or why not?

Answers will vary. The student should have an opinion of how humans act as developers, but also realize that nature too can develop new varieties of living things. This will lead them into the next section of study.

Section 2 Assignment

Marking Guide: Suggested values are given in brackets.

Comment:

For question 1, the textbook question comes from page 241 of *Science Directions 9*.

1. Answer question 7 of Checkpoint. (6 marks: 2 marks for the traits and 4 marks for the explanation of the process)

Textbook question 7. (a):

The two traits would be colour and scent.

Textbook question 7. (b):

- *Using artificial selection, select the roses with red colour and strong scent.*
- *Crossbreed the roses with these traits. As offspring emerge, these traits may or may not appear.*
- *Continue to select the offspring with the desired characteristics and use these for future breeding populations.*

2. There are advantages and disadvantages of using artificial selection to develop new varieties of plants and animals for agriculture. (4 marks: 1 mark for each of three advantages and 1 mark for one disadvantage)

   a. Describe three advantages of artificial selection.

   Advantages: better quality for the consumer, better selection for the consumer, more profit for the farmer, disease resistant varieties, reduced losses, more efficient use of resources

   b. Describe one disadvantage of artificial selection.

   Disadvantages: A loss of variation in a population can produce an inability to adapt to changing conditions of climate, disease or consumer tastes. Recent scientific research is concerned with the loss of genetic variability, which could lead to future problems when new diseases emerge and/or climatic changes occur.

Section 3: How Species Change

In this section students will see that nature also practises a form of selection. A well-adapted organism or species has a greater chance of survival and a greater chance of becoming breeding material for future generations.

Section 3: Activity 1

1. What is the problem for this investigation?

   The problem may be stated as follows: How might a predator affect a population of prey?

2. Do steps 3 to 9 of the procedure. Use the following tables to record your data. One table is for a test conducted on a large white sheet of paper, the other is for a test conducted on a large black sheet of paper. If you are working independently, you must repeat steps 6 to 9 using a second large coloured sheet of paper. If you are working with another group, each group may test a different background colour.

   Answers will vary. Following is sample data for moths on a black background.

	No. of White Moths at Start	No. of Black Moths at Start	No. of White Moths at End	No. of Black Moths at End	Total No. of White Moths with + 50%	Total No. of Black Moths with + 50%
1st Generation	*50*	*50*	*36*	*41*	*54*	*61*
2nd Generation	*54*	*61*	*33*	*51*	*49*	*76*
3rd Generation	*49*	*76*	*29*	*56*	*44*	*84*
4th Generation	*44*	*84*	*35*	*68*	*52*	*102*
5th Generation	*52*	*102*	*30*	*85*	*45*	*127*

Comment:

For question 3, the textbook questions come from page 244 in *Science Directions 9.*

3. Do questions 1, 2, and 3 of Analysis on page 244 of your textbook.

   Textbook question 1:

   a. *Answers will vary. In general, the number of white moths have a greater chance of survival on a white background.*

   b. *Answers will vary. In general, the number of black moths have a greater chance of survival on a black background.*

   Textbook question 2:

   Answers will vary, but, in general, most students will choose the contrasting colour not to survive. Sample answer: I predicted that the white moths would be easy to spot on the black paper because they are a different colour. I was correct. The white moths were collected quicker than the black moths because of their contrasting colour.

Textbook question 3:

No, because some birds can pick up the moths by their movement or just by accident as they attack the other colour of moth.

Section 3: Activity 2

1. Today most factories are trying to eliminate smoke emissions from their smokestacks. If this practice continues, what trait of the peppered moth will aid in its survival? Why?

   If the factories continue to reduce smoke emissions, the trees will have less black residue on them. The black moths will be more noticeable to the birds than the white moths. In time, the population of white moths will increase and the population of black moths will decrease because of this change in their environment.

Section 3: Activity 3

1. Summarize the steps in the process of natural selection that caused a change in the traits found in the general population of peppered moths.

   - *At first, the tree trunks around England were light-coloured. The moths that lived and fed on the tree trunks were light-coloured with dark spots. These moths sometimes produced a moth that had many dark spots or that was totally dark-coloured. These dark-coloured moths were easy for the birds to find and eat, so they did not have many successful matings to reproduce the trait.*

   - *As the cities of England grew, they produced more smoke from industries. The smoke settled in the forested areas around the industries. The smoke-darkened tree trunks no longer offered camouflage to the light-coloured moths.*

   - *The birds increasingly fed on the light-coloured moths, while the dark-coloured moths were able to mate and survive to pass on their dark-coloured traits to their offspring.*

   - *Over time, the dark-coloured moths increased in population and the light-coloured moths decreased in population.*

2. What did Darwin mean by “survival of the fittest”?

   The healthiest, strongest, smartest, quickest, and otherwise well-adapted organisms have a better chance of survival.

Section 3: Activity 4

Comment:

For question 1, the textbook questions come from page 249 of *Science Directions 9.*

1. Do questions 1 and 2 of Analysis.

   Textbook question 1:

   They developed different forms of traits because they were separated by a natural barrier. The barrier created a different environment in each area. Specific traits were needed to survive in each environment. For example, the fish in the smaller, drier lake adapted to eat the plant growth on the bottom. Their fins are wider to help them swim slowly while eating. Their mouth points downward to scrape the food off the bottom of the lake.

   Textbook question 2:

   If the water levels were to rise and create one environment, the species may not interbreed. The species may have different behaviours, adaptations, and enough genetic variation to prevent them from interbreeding. Since one fish lives at the bottom and other in the middle of the lake, they might not meet each other. They may also have different mating behaviours. Their genes might not produce fertile eggs.

2. Why do microscopic life forms develop new species in a short period of time?

   Microscopic organisms develop new species in a short period of time because their life cycle is shorter than that of more complex organisms. They multiply in great numbers very quickly.

3. Make a hypothesis. Tell how you think the following animals can be grouped according to their relatedness.

bear	horse
dog	wolf
donkey	zebra

   Students should base their hypotheses on the resemblances among the species. On the basis of physical resemblances, the dog and wolf are closely related. The horse, donkey, and zebra form another group of closely related species. The bear, being a mammal, has some relatedness to the species already mentioned, but the relationship is more distant.

4. What are the common inherited traits shared by horses and zebras?

   Some of the similar inherited traits shared by zebras and horses are strong hooves, body shape, strong legs for running, body size, and the sounds they produce.

5. How have the zebra and the horse adapted to their particular environments?

   The zebra has markings on it that make it difficult for predators to pick one particular zebra out of a moving herd. It can run fast with its strong legs and it eats the grass from the environment it lives in. The horse is also adapted to live in a grassland or prairie environment. Both horses and zebras have strong legs to run from predators, and both have a mouth and digestive system adapted for feeding on grass.

Section 3: Follow-up Activities

Extra Help

1. Which of these rabbits has the best chance to hide from a predator?

   The grey rabbit can hide more easily because it blends in with the background.

2. Give a reason why it is important to transplant a plant into a familiar environment.

   Transplanting a plant into a familiar environment will ensure the survival and continued growth of the plant. If you do not transplant it into a familiar environment, the plant may find it difficult to survive and may die.

3. If the cactus was to survive in the humid greenhouse, which traits of the cactus would enable it to survive?

   Long roots used to obtain water and nutrients and its ability to withstand the heat would be more important than its ability to conserve moisture.

4. Do question 2 of Checkpoint on page 263 in your textbook.

   Textbook question 2:

   a. *Long roots extending deep into the soil would help a plant survive in a dry environment with porous soil, such as a prairie or grassland.*

   b. *Short roots are suitable for a humid and wet environment, such as a forest or rain forest.*

   c. *Long roots that spread out close to the surface help a plant survive in rocky or mountainous environments and hard dry soils made of clay or sand.*

Enrichment

1. Describe how and why the numbers of grasshoppers increased after years of spraying.

   At first, the grasshopper population decreased because the pesticide DDT was effective on most grasshoppers. However, some of the grasshoppers were not as affected by DDT and continued to reproduce. Over many generations, the proportion of grasshoppers that was resistant to DDT increased and the pesticide eventually proved to be ineffective.

2. What other methods, besides spraying, could be used to control insect pests?

   Biological controls can be used to control insect pests. Bacteria that cause a disease that only affects grasshoppers have been developed. Birds and other predators also help to keep insect populations in check. Other methods might involve the destruction of breeding habitats or food supplies. Draining ponds can control mosquitoes. Proper waste management can reduce the number of houseflies.

3. What are the advantages of alternatives to spraying?

   These methods are less polluting and can be used to reduce consumption of chemical sprays or used on crops where sprays are not desirable.

Section 3 Assignment

Marking Guide: Suggested values are given in brackets.

Comment:

For questions 1 to 4, the textbook questions come from page 263 in *Science Directions 9*.

1. Answer question 3 of Checkpoint. (3 marks: 1 mark for the traits, 1 mark for the selection, 1 mark for the breeding)

   When first used, the rat poison was effective in killing most rats. However, the few that remained may have had a natural resistance to the particular poison, or they may have had special abilities that enabled them to recognize and avoid the poison. These traits were passed on to the next generation and some of their offspring also had the ability to resist the poison. After many generations, the number of rats that are resistant to poison increases. Soon, the population of rats also begins to increase.

2. Answer question 4 of Checkpoint. (4 marks: 2 marks for each trait)

   Answers will vary. The traits that the mice might carry follow:

   - *They may run faster.*
   - *They may camouflage better to the surroundings.*
   - *They may be very quiet.*
   - *They may be inactive during the night.*

3. Answer question 5 of Checkpoint. (4 marks: 2 each for (a) and (b))

   Textbook question 5. (a):

   Variation within a species is required because a single difference can be the factor that ensures survival when the climate or food supply changes. If a variation in a population of species does not occur, a simple change in the climate or food supply could result in the extinction of the species. For example the variation could be a strength for the species to overcome a drought and reproduce the necessary traits for continued survival.

   Textbook question 5. (b):

   The process of natural selection selects the organism with the traits most suited to the environment. Through inheritance these traits are passed on and can be selected once again.

4. Answer question 6 of Checkpoint. (4 marks: 2 marks for each trait)

   Answers will vary. Some traits that may change over time in the salamander population in the cave follow:

   - *They may develop a stronger sense of smell and hearing because they are not able to use light to see.*

   - *They may change in colour.*

   - *They may change in size.*

Section 4: Classifying Living Things

There are over a million different types of living things on Earth. Scientists have developed a system to group and classify each living thing. In this section the student will be introduced to the system of classification that was developed by Carlos Linnaeus. Using the system will involve the keen observations of similarities of living things.

Section 4: Activity 1

1. Write a brief statement that describes each of the five kingdoms of living things.

   a. Monera: *one-celled organisms with no membrane around the nucleus. They may live alone or in colonies.*

   b. Protista: *one-celled or multicellular organisms with a nucleus, special structures to move Some Protista have chloroplasts. They are not bacteria, fungi, plants, or animals.*

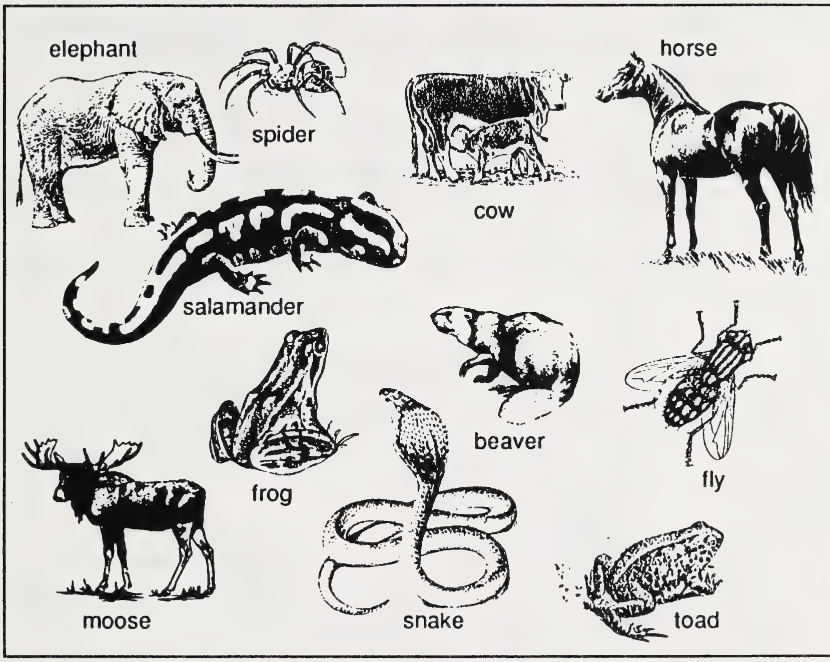
   c. Fungi: *one-celled or multicellular organisms having cell walls, but unable to produce their own food*
   They contain no chlorophyll.

   d. Plantae: *multicellular organisms with cells containing chloroplasts to produce their own food, cell walls for strength*

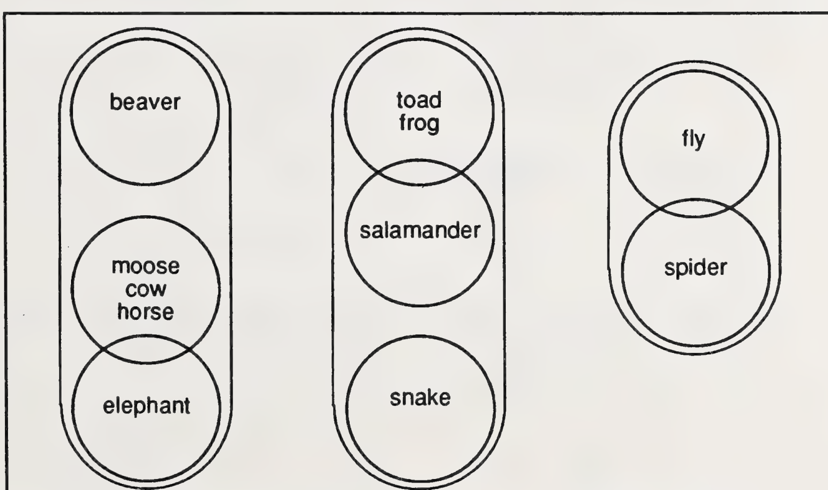
   e. Animalia: *multicellular organisms that are able to get their food by eating other organisms The cells do not contain cell walls and do not have chloroplasts to produce their own food.*

Section 4: Activity 2

1. Use diagrams that use circles and distance to indicate the general similarities and differences between the following animals.



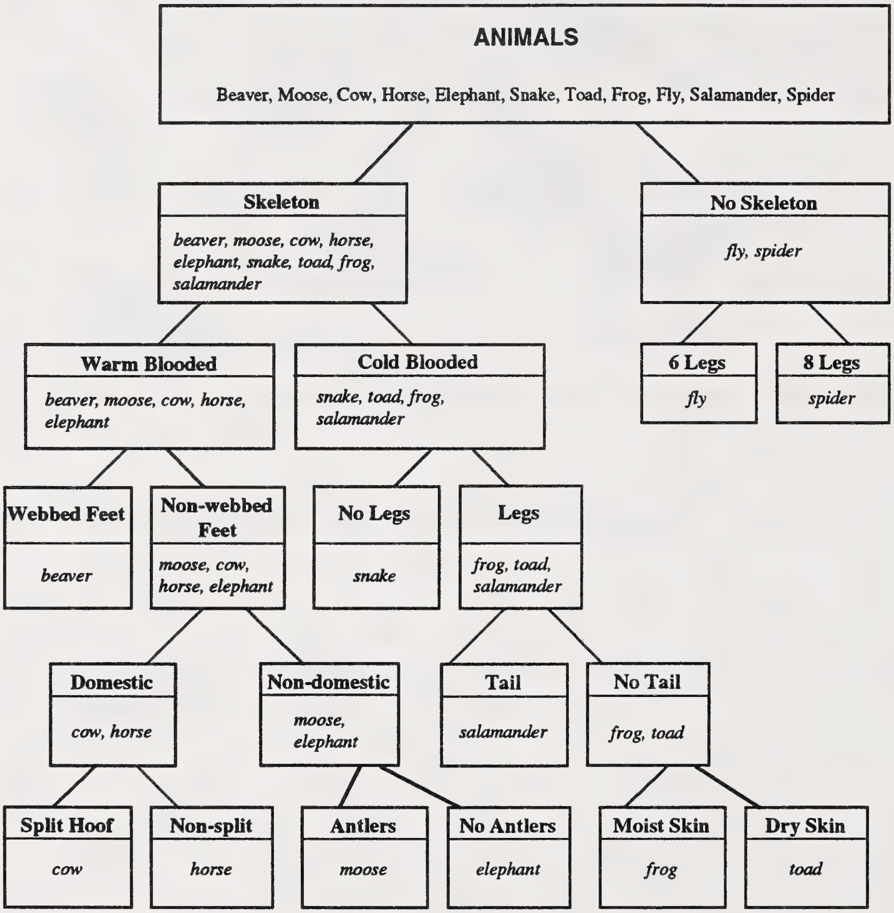
Answers will vary. Sample answer:



Students should identify three main groups or "clusters" of similar organisms.

2. Try designing your own hierarchy of the animals from question 1. Each level in the hierarchy should have a title that informs people what the grouping is based on. Use the provided space for your answer.

   Answers will vary. Look for logical basis for groupings in levels. Reasons will depend on their knowledge of visible and non-visible characteristics.



3. Name the levels of hierarchy that are used for classifying living things. List the levels in order from the most specific to the most general.

   species, genus, family, order, class, phylum, kingdom

4. Who developed the naming and classification system that uses Latin terms?

   A Swedish scientist named Carl von Linné (Linnaeus) developed the classification system that uses Latin terms.

5. Do the naming activity that is explained in Name That Species. Combine the Latin terms to create at least eight scientific names that match the common names of the animals pictured on page 257. Record your answers in the following table.

   Comment:

   Various combinations are possible. Look for capitalization of the genus portion and non-capitalization of the species name.

   Sample answers:

Common Name	Latin or Greek Name
blue jay	*Avis blueae*
salamander	*Lacerta lineatus*
bat	*Mus volans*
Canada goose	*Avis anser*
snake	*Serpis terra*
zebra	*Equus lineatus*
mouse	*Mus terra*
skunk	*Myos mephitis*

6. What are some of the differences between a lizard and a salamander?

   Salamanders have an amphibian life cycle and use gills to breathe when young. Lizards hatch directly from a fertilized egg.

7. Why are lizards and salamanders in the same phylum, but not in the same order?

   The salamander and lizard are in the same phylum because they both have a backbone, and they have similar body coverings. They are not in the same order because the salamander lives part of its life in the water using its gills to breathe. The salamander is an amphibian, while the lizard hatches from an egg and is a lung-breathing organism for the remainder of its life. The lizard is a reptile.

Section 4: Activity 3

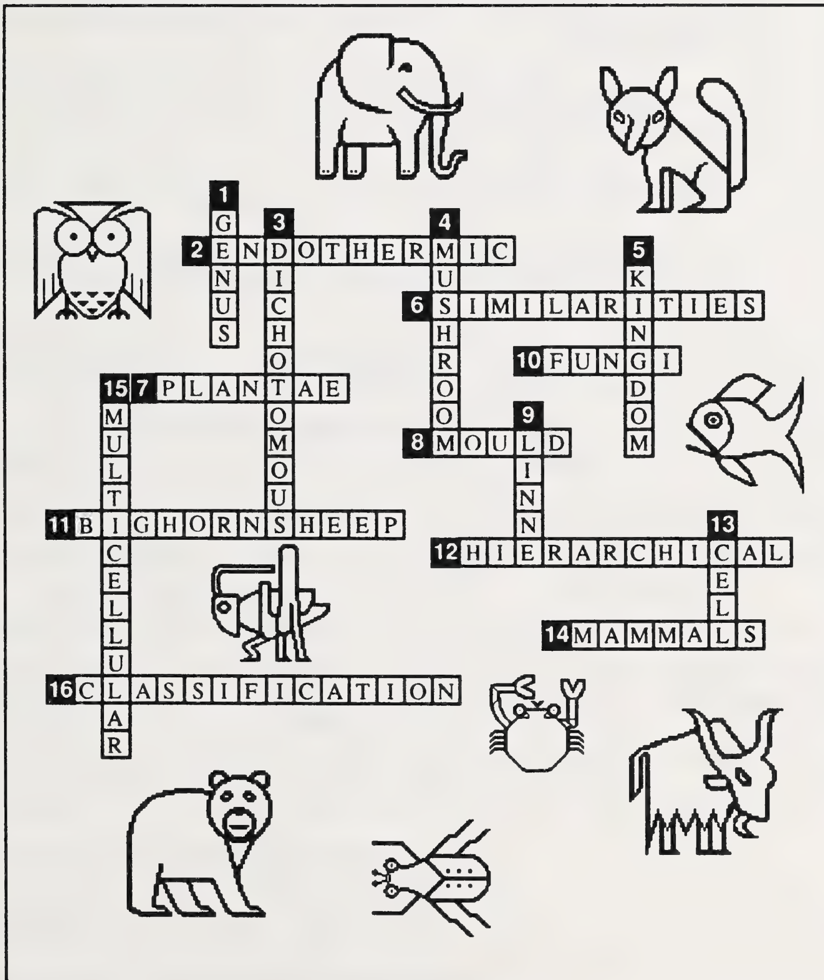
1. Do steps 1, 2, and 3 of the activity. Use the provided space for your answers.

   The students should identify the following animals

   a. *moose*
   b. *white-tailed deer*
   c. *caribou*
   d. *mountain goat*
   e. *wapiti (American elk)*
   f. *bighorn sheep*
   g. *mule deer*

Section 4: Follow-up Activities

Extra Help



Enrichment

Comment:

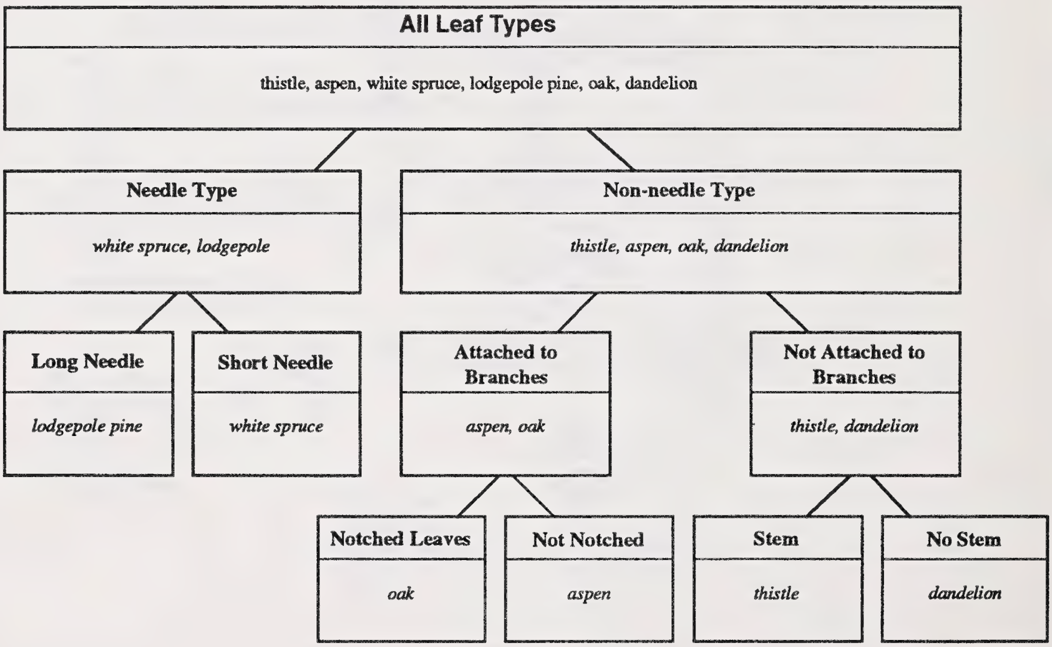
This activity comes from page 262 of *Science Directions 9.*

1. Do Activity 5-9 on page 262. In this activity you will need to obtain five to ten different leaves from trees and bushes.

   You can even find leaves in the winter! Evergreen trees, house plants, and fresh produce provide an excellent source of plant material.

   a. Use this space for your diagram.

      The first step in designing a key should be to classify the leaves by hierarchical levels. The hierarchical levels may vary. A sample is completed below.



b. Use this space for your dichotomous key.

Sample answer:

Identification Key for Leaves

Characteristics			*Identification*
1.	a.	*needle leaves*	*go to 2*
	b.	*non-needle leaves*	*go to 3*
2.	a.	*long needle leaves*	*lodgepole pine*
	b.	*short needle leaves*	*white spruce*
3.	a.	*attached to branches*	*go to 4*
	b.	*not attached to branches*	*go to 5*
4.	a.	*notched leaves*	*oak*
	b.	*not notched leaves*	*aspen*
5.	a.	*long stem*	*thistle*
	b.	*short stem*	*dandelion*

Section 4 Assignment

Marking Guide: Suggested values are given in brackets.

1. List the five kingdoms used in classification and give two examples of living things in each kingdom. (5 marks)

   Answers must include the names of the five kingdoms, but the examples will vary. More examples can be found on pages 252 to 254 in Science Directions 9.

   Monera: bacteria, baccillus, coccus, spirillum

   Protista: paramecium, amoeba, stentor, euglena

   Fungi: mushroom, bread mold, morel, toadstools, etc...

   Plant: ferns, apple tree, moss, roses, etc...

   Animal: dogs, cats, horses, birds, fish, reptiles, jellyfish, etc...

2. Explain the differences between monerans and protists. (2 marks)

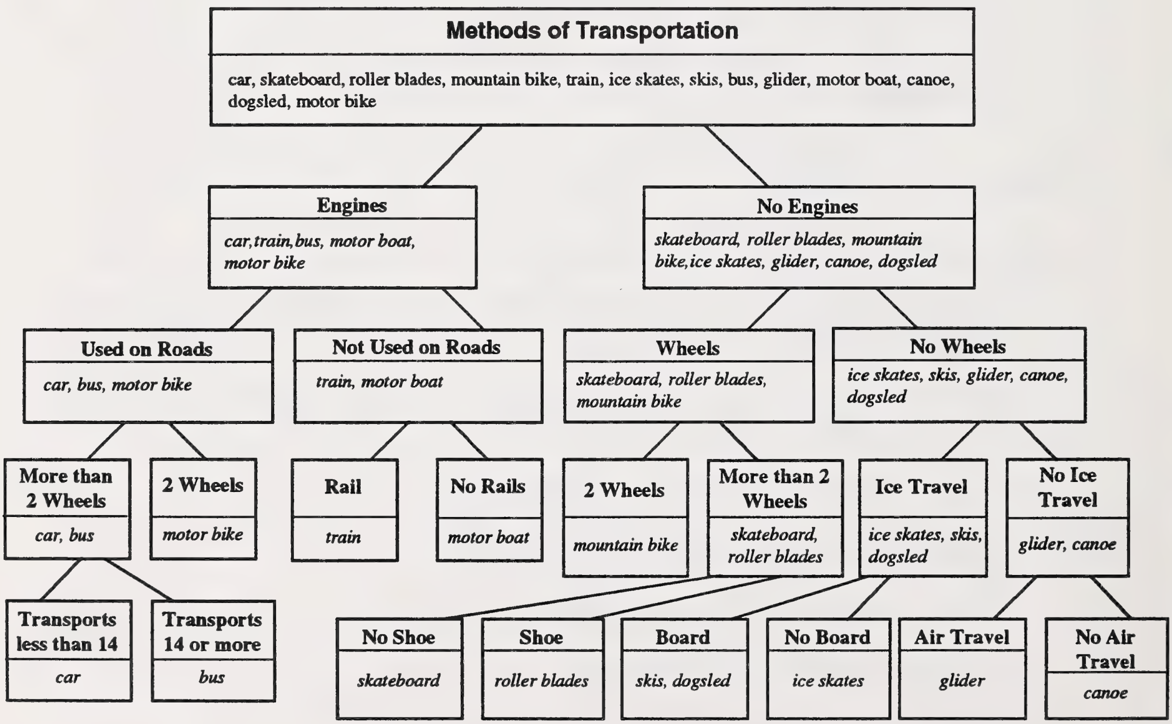
   The difference between the monerans and protists is that the monerans have no distinct nucleus in the cell and the protists do.

3. Classify the following methods of transportation into at least three hierarchical levels. Write the identifying characteristics of each group in the different levels.

car	motor boat	mountain bike
train	roller blades	motor bike
glider	skis	dogsled
skateboard	canoe	bus
ice skates		

   Your answer should include a hierarchical chart. (7 marks - 3 for levels and 4 for characteristics)

   Answers will vary. Sample answer:



4. What advantages do scientific names have over common names? (2 marks)

   Answers may vary slightly. The advantage of using a scientific name is that it is universal, no matter which language you speak. It also shows relationships. Two species with the same genus are considered to be closely related.

5. Do question 7 of Checkpoint on page 263 of your textbook. (3 marks)

   Textbook question 7. (a):

   The fox squirrel and the grey squirrel are most similar. They share the same genus Scurius.

   Textbook question 7. (b):

   The rat is most similar to the house mouse. They share the family Muridae.

   Textbook question 7. (c):

   The eastern chipmunk is most like the red squirrel. They share the same family Scuridae.

6. Do the dog and the wolf belong to the same species in the classification system? Explain why or why not. (1 mark)

   The dog and wolf have almost the same grouping because they are very similar and share many common characteristics. However, they belong to different species. For example, the scientific name for wolf is Canis lupus and the scientific name for dog is Canis familiaris.

Section 5: Similarities and Differences Among Plants

A wide variety of plants are distributed around the world. Many of the simplest plants are the ones that people are most unfamiliar with. Most people associate plants as green leafy structures. In this section students will learn the similarities and differences of the four major groups in the plant kingdom.

Students need to know the general characteristics of plants. They may wish to research more details by using other books. The life cycles of plants were covered in the Grade 8 course and students may provide more detail than is given in the suggested answers.

Section 5: Activity 1

1. Define the term *photosynthesis*.

   photosynthesis: a process that takes place in green plants. In the presence of sunlight, the plant uses chlorophyll to make a simple sugar or food from water and carbon dioxide. All green plants photosynthesize.

2. Define the term *autotroph.*

   autotroph: an organism that has the ability to make its own food

3. a. What phylum do mosses and liverworts belong to?

      Mosses and liverworts belong to the phylum Bryophyta.

   b. What environment do mosses and liverworts live in?

      They live in moist areas such as forests or swamps.

   c. What are the general features of this phylum?

      - *do not have true roots, therefore they cannot live in dry areas*
      - *conduct water via diffusion*
      - *most mosses are green, thin, tiny plants*

   d. What are the special adaptations of this phylum?

      Bryophyta can survive during dry spells by becoming dormant.

   e. What type of reproduction occurs in this phylum?

      Asexual and sexual reproduction both occur.

   f. What structure gives rise to new moss and liverwort plants?

      Spores give rise to new moss and liverworts.

4. a. What phylum do ferns belong to?

      Ferns belong to the phylum Filicinophyta.

   b. What environment do ferns live in?

      Ferns live on land, usually in moist areas such as forests.

   c. What are the general features of the ferns?

      - *have true roots and transport water through their vascular tissues*
      - *have underground stems called rhizomes*
      - *have long large leaves, called fronds, which grow up from the rhizomes*
      - *only a few known species*

d. What are some special adaptations of this phylum?

Filicinophyta can transport water quickly through the vascular tissues and a large surface on the leaves to absorb sunlight and produce more food.

e. What type of reproduction occurs in this phylum?

Ferns reproduce by both asexual and sexual reproduction during their life cycle.

Section 5: Activity 2

1. Name and describe the main difference between the two groups of seed-bearing plants.

   The two main groups of seed-bearing plants are the gymnosperms, or "exposed-seed plants", and the angiosperms, the "enclosed-seed plants". The seeds of gymnosperms are found on cones, branches, or among leaves. The seeds of an angiosperm are enclosed in a fruit.

2. a. What is the best known phylum of exposed-seed plants?

   Phylum Coniferophyta is the best known phylum of "exposed-seed plants."

   b. What are the general features of this phylum?

   - *produce exposed seeds on cones*
   - *have needle-like leaves*
   - *includes pines, spruce, fir, and cedar trees*

   c. What are the special adaptations of this phylum?

   - *Cones are used in sexual reproduction. A male cone supplies the pollen and a female cone protects the seed after fertilization.*

   - *Needles remain in place all year round so that photosynthesis is possible even in winter.*

   d. What type of reproduction occurs in this phylum?

   Sexual reproduction is used.

3. a. What group do flowering plants belong to?

   Flowering plants belong to Angiospermophyta.

b. What is the basis for division of angiosperms into families?

Variations in the structure of flowers is used to divide angiosperms into families.

c. What are the general features of angiosperms?

- *they are the dominant form of plant type on land*
- *they produce a wide variety of flowers*
- *they produce their own food and have true roots*
- *they produce a seed that is enclosed in a fruit*

d. What are some special adaptations of this group?

The main adaptations of this group are:

- *flowers that contain both male and female gametes*
- *use of insects as well as wind for pollination*
- *seeds are enclosed in a seed pod or fruit*

e. What type of reproduction occurs in this group?

Sexual reproduction is the main method used by angiosperms, although asexual reproduction is also possible.

Section 5: Follow-up Activities

Extra Help

1. Where do mosses and ferns naturally live?

   They live in moist and humid areas, such as tropical rainforests or temperate forests.

2. Which step of the moss or fern life cycle restricts them to remain in this environment?

   The step which involves pollination restricts them to a moist environment. They need water to transfer the pollen or sperm to fertilize the egg.

3. What is a seed?

   A seed is a small plant or embryo surrounded by stored rich food and a strong coating. It will grow into a new plant when conditions for growth are met.

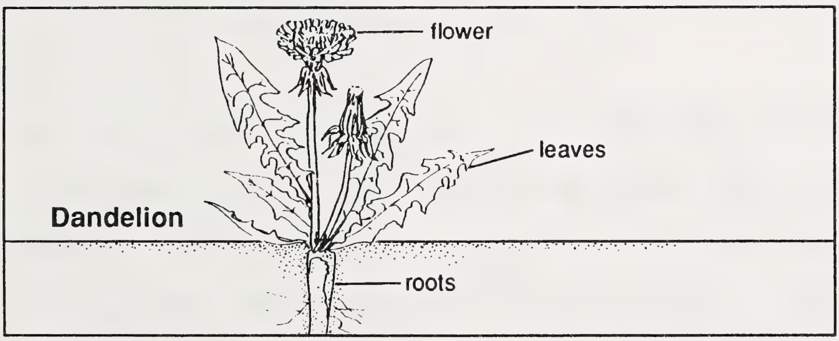
4. State two things about the reproduction of flowering plants that have made them the most successful group of plants.

   Seeds and the flowers form the basis for an efficient system of reproduction. Large numbers of seeds are produced and can be distributed over a wide area by wind, water, and other organisms.

Enrichment

1. Sketch the plant and label its major parts. Use the space provided.

   The drawing should be clear. The drawing may have more labels than shown in this example.



2. Describe the major adaptive features of the plant and its environment.

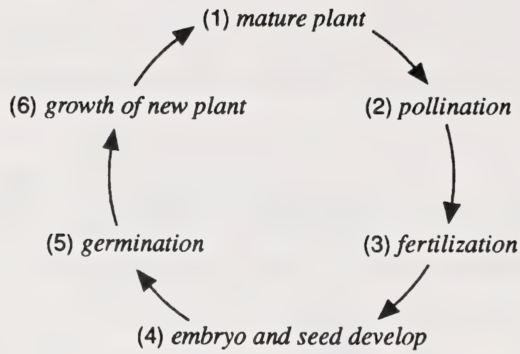
   Answers will vary, depending upon the plant chosen. Sample answer:

   The dandelion may grow almost anywhere. It needs very little moisture to survive, because it has long roots to gather water from deep down. It is known as a weed in many areas. The flower is bright yellow and is actually made up of numerous tiny flowers.

3. Draw and label the steps of its life cycle.

   Answers will vary depending upon the chosen plant. Look for general details about the life cycle. The flower produces pollen and egg cells. Pollination occurs by wind or insects. After fertilization the embryo develops into a seed. When the seed reaches a favourable site, germination occurs. The plant grows into a mature flowering plant.

Example:



Section 5 Assignment

Marking Guide: Suggested values are given in brackets.

1. What feature is found in ferns, angiosperms, and gymnosperms, but not in mosses? (1 mark)

   Mosses do not have true roots or vascular tubes for absorbing water.

2. Complete the table on the response page to compare the bryophytes (mosses and liverworts), filicinophytes (ferns), gymnosperms, and angiosperms. Answer **yes** or **no**. (4 marks: 1 mark each)

Phylum	Sperm Swim to Egg Cell for Fertilization	Roots, Stems, Leaves	Vascular Tissue	Seeds	Flowers
Bryophyta	*Yes*	*No*	*No*	*No*	*No*
Filicinophyta	*Yes*	*Yes*	*Yes*	*No*	*No*
Coniferophyta	*No*	*Yes*	*No*	*Yes*	*No*
Angiospermophyta	*No*	*Yes*	*Yes*	*Yes*	*Yes*

Comment:

For question 3, the textbook question came from page 283 in *Science Directions 9*.

3. Answer question 3 of Checkpoint on page 283 of your textbook. (5 marks: 1 mark each)

   Textbook question 3. (a):

   autotroph: organism that can photosynthesize

   Textbook question 3. (b):

   liverwort: an example of a bryophyte

   Textbook question 3. (c):

   vascular tissue: a network of conducting tissues

   Textbook question 3. (d):

   gymnosperm: plant with exposed seeds

   Textbook question 3. (e):

   angiosperm: a flowering plant

4. The female cone of the gymnosperm is found near the top of the tree and the male cone is found in the middle of the tree.

   a. What does the male cone produce? (1 mark)

      The male cone produces pollen grains containing sperm cells.

   b. What does the female cone produce? (1 mark)

      The female cone produces egg cells.

5. What are some advantages of the hard coating that surrounds the seeds of some plants? (1 mark)

   Answers will vary. The embryo and its food supply is protected from water loss. Also the hard coating can protect the structures within the seed from unfavourable external factors.

6. Use the following words to complete the chart provided on the response page.

new plant	embryo
germination	adult plant
fertilization	seed
pollination	

Fill in the blanks to describe the general life cycle of a seed-bearing plant. (7 marks: 1 mark for each answer)

General Life Cycle of a Seed-bearing Plant

(1) *adult plant*

(2) *pollination*

(3) *fertilization*
sperm + egg

(4) *embryo*

(5) *seed*
has a hard cover

(6) *germination*

(7) *new plant*

Section 6: Similarities and Differences Among Animals

Numerous types of animals live in every corner of the world. Each one is adapted to its environment. In this section students will learn about the characteristics used for classifying organisms. Students should be encouraged to use reference books for finding information on specific animals.

Section 6: Activity 1

Read the first paragraph on page 272 of your textbook.

1. Define the term *heterotroph.*

   Heterotroph: organism that obtains its energy by consuming other organisms

2. List three characteristics of animals.

   Students may select any three of the following characteristics:

   - *heterotrophic*
   - *multicellular with specialized tissues and organs*
   - *live on land, water, or inside other organisms*
   - *most are mobile*
   - *reproduce sexually or asexually*

3. Describe the basic difference between plants and animals.

   Plants manufacture their own food (autotrophs) and animals obtain their energy by consuming other organisms (heterotrophs).

Section 6: Activity 2

1. In general, which method(s) of reproduction do animals without backbones use?

   Many reproduce asexually and some reproduce sexually.

2. Name the five classes within the phylum Arthropoda.

   The five classes are crustaceans, arachnids, centipedes, millipedes, and insects.

3. Fill in the following table to summarize the information about the major phyla which represent animals without backbones. In the first column, name the phylum. In the second column, summarize the features that characterize the phylum, such as the presence of certain systems and life cycles. In the third column, name the general environment(s) that the animals in the phylum have adapted to live in.

   Answers will vary. Below are some points to look for.

Animals Without Backbones

Phylum	Characteristics of the Phylum	Environment
a. *Porifera (Sponges)*	• *simplest form of animals* • *structure like a hollow bag* • *do not have true tissues* • *large opening at the top, attached to a base* • *does not move* • *takes in water through pores* • *has flagella to swirl water to gather food* • *has no organs or systems* • *needs water to continuously flow through it to keep it alive* • *reproduces asexually by budding or by sexual reproduction* • *fertilization may occur if the water transports the sperm cells to the egg cell*	• *normally lives in salt water, but rare species appear in fresh water streams*

Animals Without Backbones

Phylum	Characteristics of the Phylum	Environment
b. *Cnidaria*	• *consist of two body types – the cylindrical body with tentacles at one end, or the umbrella body with tentacles trailing down like a parachute* • *like the sponges, they take in food and remove wastes through a single body opening surrounded by tentacles.*	• *salt water*
c. *Platyhelminthes*	• *simplest type of worm* • *flat shaped* • *most are parasites that feed upon other animals* • *non-parasitic flatworm has one opening to take in food and remove wastes* • *has a system to regulate the amount of water in the body* • *has sensory spots that respond to the stimuli of touch and light* • *by dividing into two, it can reproduce asexually, but can also reproduce sexually*	• *normally a host provides the nourishment that it needs to survive* • *non-parasitic species lives in salt water, fresh water, and damp soil*
d. *Nematoda*	• *group of roundworms that vary in size from microscopic to visible* • *are usually long, slender, and tapered at the ends* • *parasites or scavengers* • *bodies have a simple form of digestion, excretion, and nervous systems*	• *plants and animals that can provide them with the nutrients* • *terrestrial and aquatic forms*
e. *Annelida*	• *these worms are rounded, slender, long, and segmented along their bodies* • *simple forms of digestive, circulatory, nervous, and excretory systems*	• *moist, damp soil* • *fresh and salt water*

Animals Without Backbones

Phylum	Characteristics of the Phylum	Environment
f. *Mollusca*	• *large group of animals that have soft bodies or soft bodies with a hard covering for protection* • *have well-developed nervous, circulatory, digestive, excretory, and gas-exchange systems* • *secrete a substance in the mantle to form a shell; even the animals with soft bodies secrete this substance.*	• *fresh water, salt water, and land*
g. *Echinodermata*	• *all have bodies that are circular or radial and have appendages stemming outward* • *usually have five or more appendages radiating from the body* • *tube feet (suction cup-like) on each appendage help them move about* • *they have hard spines on the outer layer of their body* • *mouths for feeding and well-developed nervous and digestive systems* • *circulating water entering from the mouth serves the purpose of a simple circulatory, excretory, and gas-exchange system*	• *salt water*
h. *Arthropoda*	• *largest and most diverse phylum of animals* • *a hard outer covering (exoskeleton) like a shell prevents water loss and provides protection* • *jointed limbs or appendages* • *distinct numbers of body sections* • *some have wings for flight, others have strong legs for jumping* • *most or all reproduce sexually*	• *salt and fresh water and on land*

Section 6: Activity 3

1. What types of environments do chordates live in?

   Chordates live on land, in fresh water, and in salt water.

2. Name the dominant sub-phylum in the phylum Chordata.

   The dominant sub-phylum is sub-phylum Vertebrata.

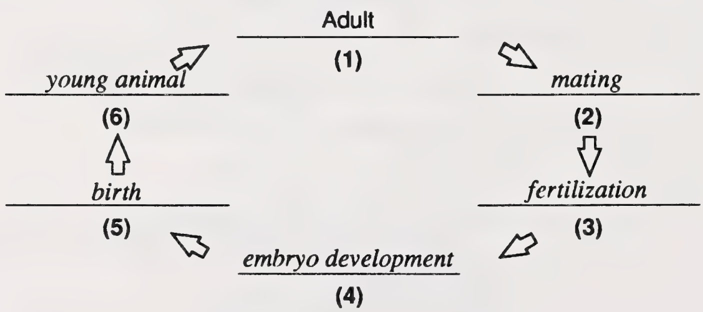
3. What does the term *vertebrate* mean?

   A vertebrate implies having a nerve cord encased by bones along the back of an animal.

4. What are the six main groups of vertebrates?

   The six main groups of vertebrates are jawless fish, jawed fish, amphibians, reptiles, birds, and mammals.

5. Use the information from the text and the previous statement to fill in the steps for the general life cycle of most vertebrates.



6. Fill in the chart to highlight the characteristics, environments, and names of common species of chordates.

Answers will vary. The following information is included to help you evaluate student responses.

Class	Major Characteristics and Adaptations	Environment	Species
Jawless fish	• *adapted for sucking* • *attaches itself to a body of another fish so it can suck food from it*	• *lives in a water environment*	• *only two species known (one is the lamprey)*
Jawed fish (cartilage)	• *These fish have strong jaws to capture food and to eat their food.* • *body systems include the circulatory, digestive, excretory, respiratory, reproductive, and nervous systems* • *have scales as a protective covering* • *skeleton is made of cartilage, making the body flexible*	• *environment is aquatic*	• *common species is the shark*
Jawed fish (bony)	• *strong jaws enable the fish to eat and consume food easily* • *breathe in oxygen from the water with gills* • *body systems include the circulatory, digestive, excretory, respiratory, reproductive, and nervous systems* • *have scales as a protective covering* • *bones make up their skeleton*	• *environment is aquatic*	• *includes salmon, tuna, pike, and trout*

Class	Major Characteristics and Adaptations	Environment	Species
Amphibians	• *moist skin covers their bodies* • *breathe with gills during early part of life cycle; as they mature they develop lungs* • *body systems include the circulatory, digestive, excretory, respiratory, reproductive, and nervous systems*	• *live near or in water environments*	• *includes frogs, salamanders, toads, and newts*
Reptiles	• *body systems include the circulatory, digestive, excretory, respiratory, reproductive, and nervous systems* • *lay eggs with tough coverings so they do not dry out*	• *skin is dry and scaly. This enables them to live in many environments (water, moist land, and dry arid land).*	• *common species are snakes, turtles, lizards, and crocodiles*
Birds	• *have skin covered with a layer of feathers* • *well-adapted for flight because their bones are light and hollow* • *body systems include the circulatory, digestive, excretory, reproductive, and nervous systems* • *lay eggs and incubate them to produce young* • *many have beaks and produce unique sounds* • *have wings and two feet*	• *live in many land environments (wetland, alpine forest, desert, shoreline)*	• *common species are numerous (robin, meadow lark, penguin, and Canada goose)*
Mammals	• *all mammals have a layer of skin for protection and coating of hair or fur* • *they are warm-blooded* • *body systems include the circulatory, digestive, excretory, reproductive, and nervous systems* • *give birth to live young* • *female produces milk in the mammary glands to nourish the young*	• *live in salt or fresh water and live on many different land environments*	• *common species are humans, elephants, whales, cows, mice, cats, and seals*

Section 6: Follow-up Activities

Extra Help

1. Create a phrase or riddle to help you remember a major feature of each of the major groups of animals. The first one is done as an example.

   Answers will vary, some may be quite humorous. The following are sample answers only:

   a. Porifera: all pores, mouth, and water

   b. Cnidaria: *tentacle dancers*

   c. Platyhelminthes: *one-eyed flat arrow head*

   d. Nematoda: *sneaky round worm*

   e. Annelida: *down to earth and segmented*

   f. Mollusca: *the soft body with a hard shell*

   g. Echinodermata: *the five-arm sucker*

   h. Arthropoda: *wild and free critters*

   i. Chordata: *the animals we know best*

2. Fill in the blanks with the appropriate word or phrase about animals.

   a. Insects belong to the phylum *Arthropoda* .

   b. A soft-bodied animal that has many tentacles is the *octopus*.

   c. A type of flatworm which is parasitic is the *tapeworm or fluke*.

   d. The simplest class of vertebrates with only two living species is the *jawless fish*.

   e. Birds are the only animals which have *hollow bones for flight and feathers*.

   f. The class of vertebrates which lay leathery eggs are the *reptiles*.

   g. A *life cycle* represents the stages of the development of most animals.

Enrichment

Students may do either Part A or Part B.

1. Choose an animal and write a short animal adventure story about it. The story must contain a setting (where the animal lives) and a detailed description of the animal. Be creative and give your animal a personality, but be specific to the animal you are writing about. Use this space for your good copy. If you need more space, you may use your own paper.

   The story should contain the details about the animal of choice. The adventure may be written in a narrative form. Stories will vary and should be very enjoyable.

2. Do steps 1 and 2 of the procedure.

   The three major groups include:

   - *animals with six legs: a, c, f, h, i, j*
   - *animals with eight legs: b, g*
   - *animals with eight or more legs and many body segments: d, e*

   The largest group can be sub-divided into those with

   - *single pairs of wings*
   - *more than one pair of wings*

Comment:

For question 3, the textbook questions come from page 278 in *Science Directions 9*.

3. Answer questions 1, 2, and 3 of Analysis.

   Textbook question 1:

   They have jointed limbs, segmented bodies, and have a hard outer covering or exoskeleton.

   Textbook question 2:

   The number of legs is an easily identifiable trait that is common to closely related species.

   Textbook question 3:

   The number of segments in the abdomen, type of respiratory system, or mouth pieces could be used for further subdivision.

Section 6 Assignment

Marking Guide: Suggested values are given in brackets.

1. Fill in the blanks on the response page with the appropriate words. (6 marks: 1 mark each)

   a. The body of a *porifera or sponge* is a double layer of cells which are not arranged into true tissues.

   b. *Cnidarians* are hollow animals with tentacles.

   c. *Annelids* have soft bodies and are divided by rings.

   d. *Arthropods* have jointed legs and an outside skeleton which they shed.

   e. Fish, reptiles, birds, and mammals are *chordates*.

   f. *Molluscs* have soft bodies and a hard shell.

2. Answer question 5 of Checkpoint on page 283 of your textbook. (2 marks)

   The sea anemone and the jellyfish have appendages that radiate from the centre of the body. They have simple digestive, circulatory, and nervous systems. The sponge is not similar to these because the sponge is a very simple animal with no systems to carry on life processes. It can only manage to diffuse food and oxygen into its cells from the surrounding water.

3. Answer question 10 of Synthesizer on page 285 of your textbook. (4 marks: 2 marks for each part)

   Textbook question 10. (a):

   Birds and bats are classed in different phylums than butterflies because birds and bats have a vertebrate or backbone and the butterflies do not.

   Textbook question 10. (b):

   Birds are grouped into one class because they have an outer covering of feathers and bats have an outer covering of skin and hair. The birds also lay eggs, while bats give birth to live young and nourish their young with milk produced by the female.

4. Name the phylum into which each animal is classified. (8 marks: 1 mark each)

a. deer — *Chordata*

b. peppered moth — *Arthropoda*

c. jelly fish — *Cnidaria*

d. coral — *Cnidaria*

e. seal — *Chordata*

f. sea snail — *Mollusca*

g. earthworm — *Annelida*

h. lobster — *Arthropoda*

SCIENCE 9

Module 6

Environmental Quality

LEARNING FACILITATOR'S MANUAL

Distance Learning

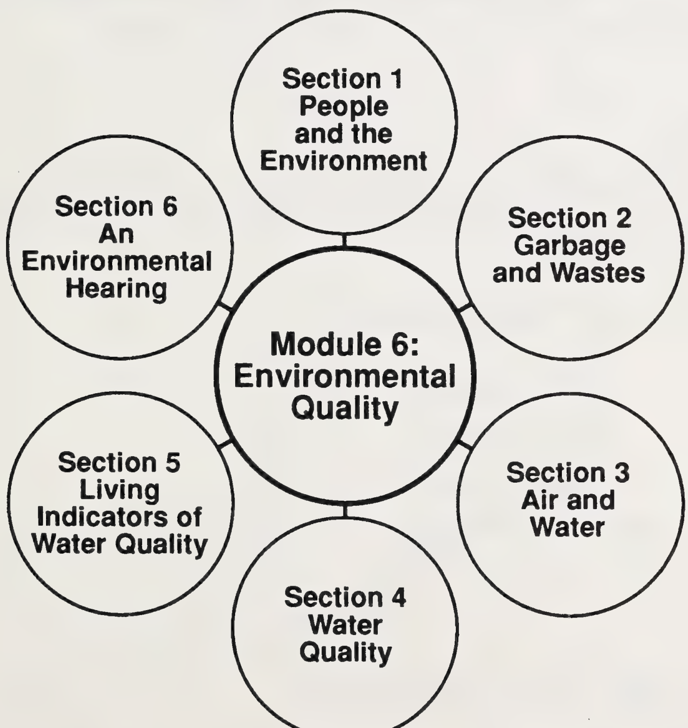
Alberta EDUCATION

Module 6: Environmental Quality – Overview

The environment is a subject that students hear about or read about almost every day. Their viewpoints on environmental issues have been shaped by many factors.

In this module students will be given an opportunity to objectively evaluate various viewpoints. They will consider perspectives and alternatives, and then, by evaluating the effects of actions and the decision-making process, they will develop a personal awareness of the impacts of human actions on environmental quality. In this module students will be introduced to the idea of environmental quality and the role of science in monitoring that quality. The students will learn that personal and public decisions regarding environmental quality are needed and that the decision-making process should be informed by knowledge of environments and objective assessments of environmental impacts. This module also gives students the opportunity to look at the long-term and short-term impacts of human actions within different environments.

Environmental quality indicators such as air, water, and soil quality are considered. Students examine a sample of water in the way that an aquatic biologist would and play a realistic role in a mock environmental hearing.



Classroom Opener

- Brainstorm some things that people and animals need from the environment.
- Brainstorm some things that people enjoy in their environment.
- As a pretest of the students' knowledge, you might ask them to suggest some of the things that degrade the environment.
- Discuss what is meant by *environmental quality*.
- Introduce this module as a demonstration of the ways that science can be used to monitor and detect changes in the environment that may show a loss of environmental quality.

Materials and Equipment

A list of the equipment and materials needed for some activities is provided along with comments on these activities in following sections. The equipment listed is for an individual or a small group. Adjust the amount of equipment if more than one individual or group is involved.

Evaluation

The mark in this module will be determined by students' work in the Assignment Booklet. Students must complete all assignments. In this module students are expected to complete five section assignments and a final module assignment.

The assignment breakdown is as follows:

Section 1 Assignment	**10%**
Section 2 Assignment	**15%**
Section 3 Assignment	**15%**
Section 4 Assignment	**10%**
Section 5 Assignment	**10%**
Final Module Assignment	**40%**
TOTAL	**100%**

Section 1: People and the Environment

In this section students study the growth of populations and some of the pressures that population growth puts on the environment. Students will learn to identify issues and the viewpoints expressed by statements and opinions.

Section 1: Activity 1

1. What has enabled people to make major changes to their environment?

   They discovered how to use the energy stored in fuels such as coal and water.

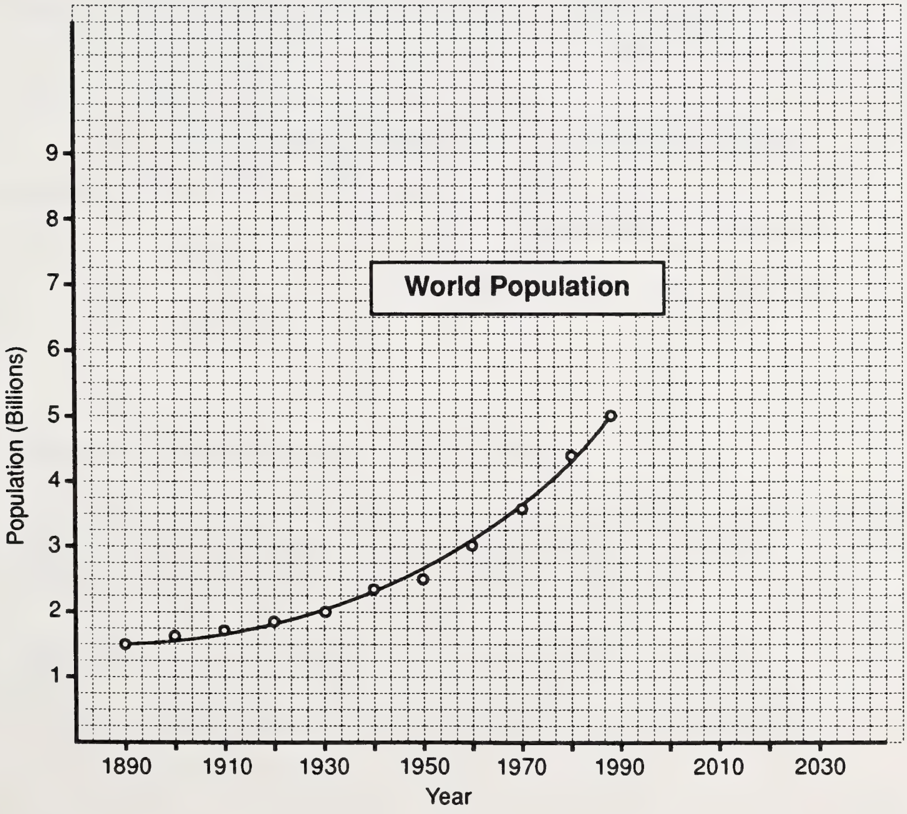
2. Explain what is meant by a "population explosion".

   Earth's population has increased from 1.5 billion in 1890 to 5 billion in 1990. Earth's population is doubling in only thirty to thirty-five years!

3. What is the problem for Part A of Activity 6-1?

   How is the world population changing?

4. Do the procedure for Part A. Plot your graph on the grid provided.



5. Do question 1 of Analysis.

   Students may predict that the trend will continue and cite reasons such as improved health care, better sanitation, and improved food distribution systems. Some students may predict that the trend will not continue and cite collapse of the global economy, disasters, or even the AIDS epidemic as reasons for the population growth to cease.

6. Do question 2 of Analysis.

   Students may suggest widespread famine, war, new diseases, or birth control as reasons leading to population decrease.

Section 1: Activity 2

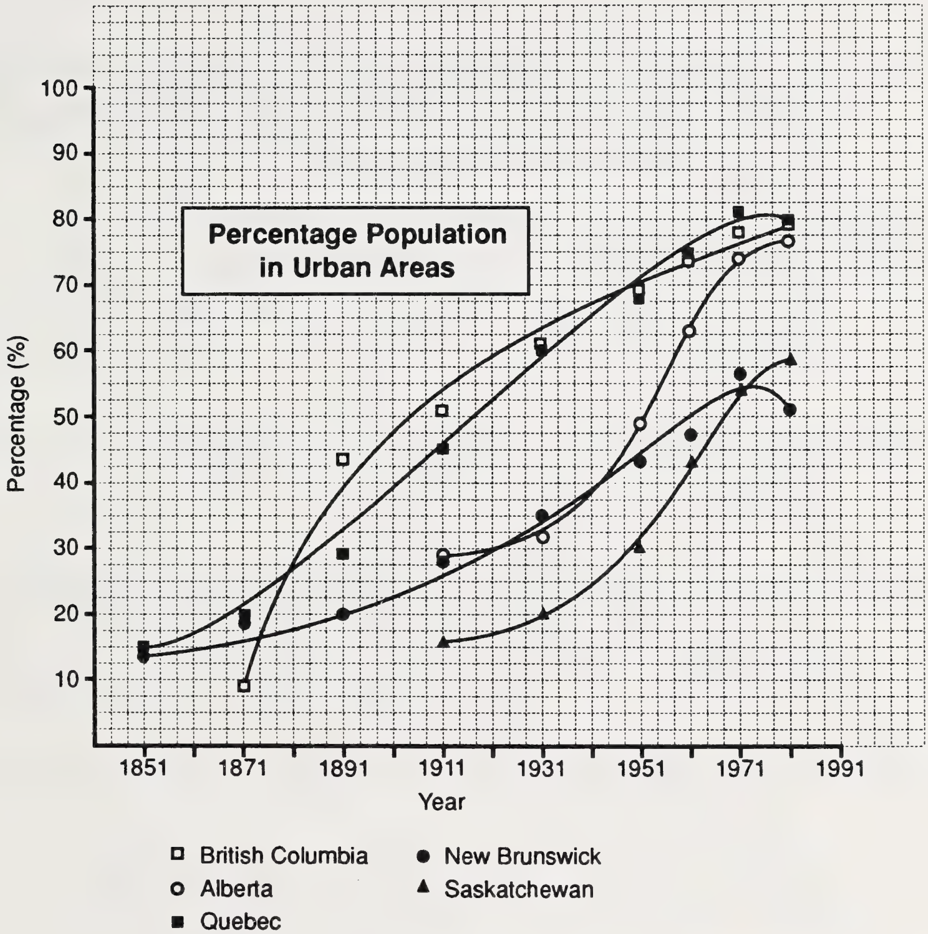
1. What are two main factors responsible for the human population explosion?

   The first factor was the discovery that microorganisms cause disease. This led to more sanitary conditions, improved medical treatment, and improvements in food production. The second factor was the development of industrialization through the invention of machines that improved production and transportation.

2. Do the procedure for Part B. Plot your graph in the grid provided.

   The shape of the lines on the graph will vary, depending on which five provinces were selected from Table 6-2 in the textbook.

   The graph is shown on the next page.



3. Do question 1 of Analysis on page 290 of your textbook.

All provinces show a general increase in the percentage of urbanization over the time period recorded. British Columbia had the greatest urbanization in the early part of this century, while Alberta has had the greatest urbanization in the last thirty years.

4. Do question 2 of Analysis.

The trend is for more people to move to the cities (urban areas) as time passes.

5. Do question 3 of Analysis.

   The general trend is towards urbanization. This trend will continue. A contributing factor is that farm equipment allows an individual to farm a much larger area now, as compared to the pioneer days. This means that it takes fewer farmers to farm large areas of land. A second factor is that farming has not been very profitable in recent years.

6. Do question 4 of Analysis.

   Percentage allows comparison. Raw data would not provide meaningful information which could be used for comparison.

7. Define *urbanization.*

   Urbanization is the trend of movement towards urban areas.

8. What are the two major impacts of a densely populated city on a relatively small area?

   The two major impacts of a city are a large daily input of materials and energy and a large daily output of wastes.

Section 1: Activity 3

1. Define the word *issue*.

   An issue is a matter about which different people have different viewpoints.

2. What makes an issue science-related?

   Concern that knowledge is obtained by objective observation and scientific experimentation makes an issue science-related.

3. Identify the appropriate viewpoints for Issue C. Remember that each issue has more than one viewpoint.

   Answers may vary. Some examples are given.

   a. ecological:

      Oil and gas development disturbs or destroys wildlife. Oil and gas companies should be restricted from drilling in areas that contain rare plants and animals.

b. economic:

The oil and gas industry provides a lot of jobs both directly and indirectly. If they don't drill here, they will go elsewhere and take the jobs and the economic growth with them.

c. ethical/moral:

It is not right that plants and animals will have their habitats ruined by the action of the oil and gas industry. Student may also state that it is not right that many people will be left jobless because the concerns of a few people for a few plants and animals prevents the drilling projects.

d. health-related:

The peace and quiet of the natural areas will be disturbed by the action of the oil and gas industry and people will no longer be able to get rest and relaxation from visiting such areas.

e. political:

Many jobs are related to the gas and oil industry. These jobs are represented by voters whose interests must be served before the interests of the wildlife.

4. Should a viewpoint be considered right or wrong?

A viewpoint is neither right nor wrong. It must be considered in terms of where it is coming from.

5. Do steps 1 and 2 of the procedure. Write the issue in the form of a statement.

Answers will vary. Sample issue: Should a catch and release program be instituted in the Bow River between Canmore and Seebe?

6. Do step 3 of the procedure.

Answers will vary. Examples:

ecological: If the fish are released, then there will be a greater population which will survive in the river.

recreational: Only some of the people who fish like to release their catch. Others get enjoyment from the fish they can take home and eat.

7. Do steps 4 and 5 of the procedure.

   Answers will vary. The learning facilitator should look for the title and source of the article, and a sentence or two which describe what the article has said.

8. Do step 6 of the procedure.

   Answers will vary. The learning facilitator should look for points that have to do with specific studies – may include the data collected, the hypotheses, or the conclusions of the scientists.

9. Do step 7 of the procedure.

   Answers will vary. The learning facilitator will notice opinions expressed by interest groups such as politicians, industry spokespersons, or emotions shown by the various stakeholders.

10. Do steps 8 and 9 of the procedure. Use the following table to compare viewpoints presented in at least two different articles.

    Answers will vary but a valid point should be made for each article opposite the following headings: ecological, economic, educational, egocentric, ethical/moral, health-related, recreational, political, scientific, technological.

11. Do question 1. (b) of Analysis.

    It is very easy to state a viewpoint with the way that an issue is stated. Students should become aware of their own viewpoints.

12. Do question 2 of Analysis.

    Student answers will vary. Some inferences are based on the opinions of expert witnesses. It is important to determine if the quoted persons are truly experts in the areas that they are speaking about.

13. Do question 3 of Analysis.

    Answers will vary depending on the topic and the articles.

14. Do question 4 of Analysis.

    Answers will vary depending on the topic and the articles.

15. Do Further Analysis question 5. This question may be used to complete a portion of your final module assignment. You should begin researching and collecting information on your topic and continue working on it throughout the rest of this module.

    Students should be collecting information about the issues they have chosen.

Section 1: Follow-up Activities

Extra Help

1. Match the viewpoint listed in Column A to the statements presented in Column B. Write the appropriate letters from Column A into the blanks before the statements in Column B.

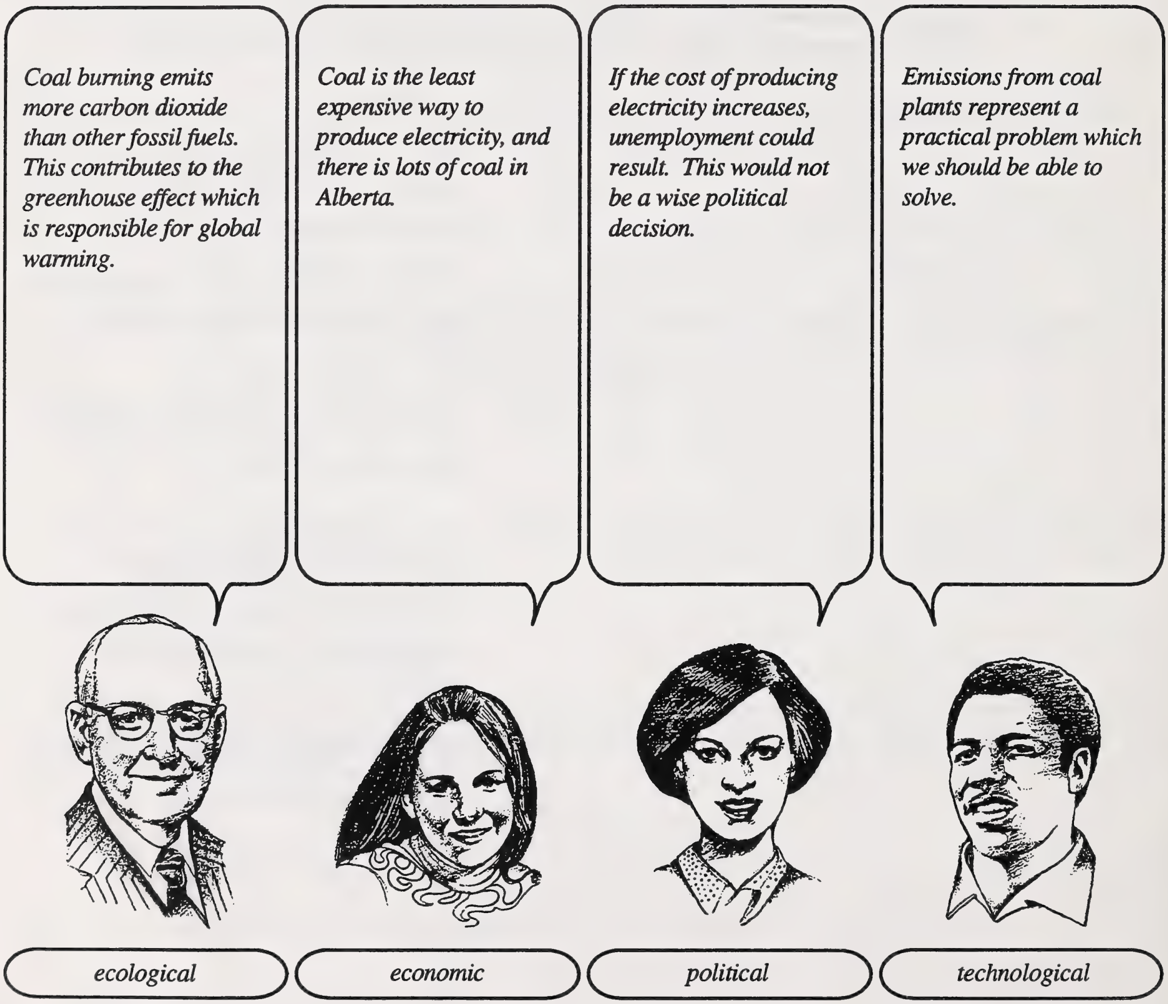
Column A	Column B
a. ecological	*c* This is the last long weekend of the summer and the last chance many people get to go camping before winter.
b. economic	*e* The bears need to move into the valleys to feed. This allows them to prepare for hibernation.
c. recreational	*a* The bears belong in that environment and the campers are the intruders. Campers should be kept out.
d. political	*b* If the campground is closed, the local store will have to lay off four of the seasonal workers before the long weekend. The workers were counting on the extra wages to pay for tuition at college next year.
e. scientific	*d* If the campground closes, the Minister of Recreation and Parks will receive a lot of angry letters and phone calls.

Enrichment

Refer to page 293 in your textbook. Consider Issue E on the burning of coal. Use Issue E to answer the following question.

In the sketch below, write out a possible viewpoint statement in the dialogue bubble for each of the characters. Identify the viewpoint of each character in the box below each figure.

Answers will vary. Sample answers are provided.



Section 1 Assignment

Comment:

For questions 1 and 2, the textbook questions come from page 303 in *Science Directions 9*. For question 1 check to see that the student uses each term correctly in a sentence in addition to defining each term.

Marking Guide: Suggested values are given in brackets.

1. Answer question 1 of Checkpoint. (4 marks)

   Textbook question 1. (a):

   urbanization: the movement of people from rural to urban areas

   Textbook question 1. (b):

   environmental issue: a matter involving the environment that involves different viewpoints

   Textbook question 1. (c):

   pollution: anything that is added to the environment that causes harm to living things or degrades the environment

   Textbook question 1. (d):

   biodegradable waste: waste that can be broken down through the actions of living things

2. Answer question 2 of Checkpoint. (6 marks)

   Textbook question 2. (a):

   the human population explosion: A growing population requires an ever increasing supply of energy and resources. This in turn produces a greater amount of personal and industrial waste.

   Textbook question 2. (b):

   urbanization: A greater concentration of people means that a large amount of solid waste, sewage, and air pollution must be absorbed by a small area.

   Textbook question 2. (c):

   industrialization: Industry consumes a large amount of energy resources and releases carbon dioxide and other gases into the atmosphere. A large volume of other waste products must also be disposed of, many of these being toxic.

Section 2: Garbage and Wastes

In this section the students will monitor and classify wastes and look at methods of waste disposal. Students will consider the ways that they, as individuals, influence the amount of solid wastes they produce each day.

Section 2: Activity 1

The following equipment is needed:

- six grocery bags
- a bathroom scale or spring scale capable of weighing to the nearest 0.5 kg

1. Define *solid waste.*

   Solid waste is a type of litter, trash, or garbage which accumulates in large quantities.

2. How much solid waste, on average, does each person in Canada discard per year?

   On average, each Canadian produces more than 400 kg of household garbage per year.

3. How much solid waste, on average, does each person in Canada discard per day?

   On average, each Canadian produces just over 1 kg of solid waste per day (400 kg/year 365 days = 1.09 kg/day).

4. Do you think that you produce more or less solid waste than the average Canadian? Explain your answer.

   Answers will vary. Example:

   I am not very careful about reducing wastes. I produce more solid waste than the average Canadian.

   I am careful to reduce and reuse – this produces less than the average amount of garbage.

5. What is the problem for this investigation?

   How much of different types of wastes do you produce?

6. How many bags do you intend to use for this activity?

   Answers will vary. Four to six would be a reasonable range.

7. List three factors that might influence your results.

   The following conditions might influence your results:

   - *the time of year the sample is taken*
   - *if the various food containers have just been opened, or just finished off*
   - *if there has been a large party at the house*
   - *if the family has gone out of the house for a meal to a restaurant or to another person's house*

8. Record each type of waste in the space provided. Rank each type of waste as described in step 4 of the procedure.

   Answers will vary. Possible categories include newspapers/magazines, glass/metal cans, plastics, wet garbage (slops), and boxes and dry trash.

9. Do questions 1 and 2 of Analysis.

   Textbook question 1. (a):

   Newspapers will have the greatest mass, followed by glass and metal. If newspapers are not received in the house, then the glass and metal will have the greatest mass.

   Textbook question 1. (b):

   Generally, paper has the greatest volume.

   Textbook question 2:

   Answers will vary. Possible answers include measuring for more than two days so that the average is more meaningful.

Section 2: Activity 2

1. What is a sanitary landfill site?

   A sanitary landfill site is where incoming waste is compacted to reduce its bulk and covered over with soil to prevent the spreading of litters and chemicals.

2. What is the difference between wastes that are biodegradable and wastes that are non-biodegradable?

   Biodegradable wastes can be broken down and used as food by living organisms. Non-biodegradable wastes cannot be broken down and used as food by living organisms.

3. What is an important consideration in choosing the site for a sanitary landfill?

   Landfill sites are chosen to avoid the possibility of any toxic wastes entering the water supply by seeping into ground water.

4. Why do some materials that are not dangerous while they are being used become dangerous when they are discarded as wastes?

   The materials are not dangerous in the home, but when they are discarded they can dissolve in water and be carried elsewhere. Cadmium is the example given in the textbook.

5. What dangers do these materials present to the environment?

   These chemicals may enter the food chain. Animals at the top of the food chain, including humans, may be affected.

6. Write a short paragraph which describes how individuals and communities can reduce the volume of solid waste that they produce.

   Answers will vary, but the learning facilitator should look for the four Rs of waste management. These include reducing, reusing, recycling, and recovering.

Section 2: Follow-up Activities

Extra Help

1. Describe the four Rs of waste management and give an example of how you could use each method.

   a. reduce

      to decrease the amount of wastes produced. The simplest way to reduce is to look for packaging that is not excessive.

b. reuse

to use things for the same purpose more than once or to use them for a new purpose. Refillable canisters can be used to store bulk foods, rather than buying prepackaged foods.

c. recycle

to collect wastes of a certain type so that they can be broken down and rebuilt into a new product. Bottles can be used to produce stucco.

d. recover

to reclaim waste material or energy and to put it to another use. Waste industrial heat can be used to heat a greenhouse.

Enrichment

Write a short paragraph describing your proposals.

Answers may vary. Students may suggest a blue box system for the school or the neighbourhood, if these are not already in place. Students may come up with new ideas on the problems related to packaging. In many cases, the excessive packaging of small items is prevention against theft, which is also a major problem for merchants. Keeping small items under lock and key reduces sales.

Section 2 Assignment

Comment:

For questions 1 to 6, the textbook questions come from page 303 in *Science Directions 9.*

Marking Guide: Suggested values are given in brackets.

1. Answer question 3 of Checkpoint. (3 marks)

   If groundwater is slightly acidic, it has the ability to corrode metals and carry them away in solution. These metals will then be transported to rivers and streams.

2. Answer question 4 of Checkpoint. (3 marks)

   If poisons are fat soluble, they accumulate in an organism throughout its life. Because a food pyramid has fewer organisms at the top, these organisms consume all of the accumulated poisons stored in all of the prey that they have eaten.

3. Answer question 6 of Checkpoint. (2 marks)

   The plastic candy wrapper will take much longer to break down than the apple core. The apple core is biodegradable.

4. Answer question 7 of Checkpoint. (3 marks)

   Answers will vary. Some examples include:

   - *Buy enviropaks and refill the original containers.*
   - *Select items that have reduced packaging.*
   - *Return bottles and cans to the bottle depots.*
   - *Establish compost heaps.*
   - *Reuse lunch bags.*

5. Answer question 8. (a) of Checkpoint. (1 mark)

   It is important to reduce the volume of wastes (since the landfills are filling up).

6. Answer question 13 of Checkpoint. (3 marks)

   Possible answers include:

   - *Cars require more energy than horses.*

   - *More electricity is used in a large city.*

   - *A large city will produce more garbage, which in turn will require more energy for disposal.*

Section 3: Air and Water

In this section the students will identify some of the indicators of air quality and discover how pollutants can negatively affect the quality of the environment.

Section 3: Activity 1

1. In what way is Earth like a spaceship?

   Earth carries its own air and other supplies and its inhabitants depend on the recycling of materials within it.

2. Why was the word *smog* not used until the late 1800s?

   It was not until the 1800s that coal smoke and fog led to problems in major industrial cities. A word which resembled a combination of smoke and fog was needed to describe these problems.

Comment:

For question 3, the textbook questions come from page 306 in *Science Directions 9.*

3. Complete questions 1 to 4 from this activity.

   Textbook question 1:

Polluting Gas	**Major Source**
carbon monoxide	*vehicle exhaust*
nitrogen oxides	*vehicle exhaust*
sulphur oxides	*industrial processes*
hydrocarbons	*vehicle exhaust*
particulates	*industrial processes*

   Textbook question 2:

   Vehicle exhaust is the greatest source of pollution.

   Textbook question 3:

   Forest fires seem to be a major natural source of these gases.

   Textbook question 4:

   Answers may vary. Any answer which suggests a reduction in vehicular traffic is acceptable. Some suggestions might include the following: provide efficient and rapid public transit; encourage gas efficient vehicles through taxation or licensing; reduce the amount of parking available in an area, forcing public transit or car pools.

Section 3: Activity 2

1. What are the two main pollutants that cause acid rain?

   Sulphur and nitrogen oxides produced by ore smelters, coal-fired electrical generating stations, and paper mills are the two main pollutants that cause acid rain.

2. What is the pH of acid rain?

   Acid rain has a pH lower than 5.6.

3. What are three main effects of acid rain?

   - *Acid rain causes chemical changes in soil and water that can reduce soil fertility, retard tree growth, and kill animal and plant life in lakes.*

   - *Acid rain can corrode exposed metal surfaces and eat away stone statues and limestone buildings.*

   - *Acid rain can result in the leaching of toxic chemicals, such as mercury, from the soil into the waterways.*

4. Why is acid rain less destructive in some areas than in other areas?

   In some areas limestone underlies much of the land. Limestone neutralizes acids. In other areas the bedrock is mostly granite and cannot neutralize acid rain. As a result, these type of areas become increasingly acidic.

5. List three measures that have helped reduce air pollution in the last twenty years.

   - *Emissions of sulphur dioxide have been reduced by the development of tall smokestacks that dilute emissions and by the introduction of scrubbers that remove the emissions.*

   - *Air pollution has been reduced by the use of fuels which contain less sulphur, such as natural gas or alternate forms of fuel.*

   - *Air pollution has been reduced by stricter controls on automobile emissions, such as the catalytic converters required by law since the 1970s.*

Section 3: Activity 3

1. What are four ways that pollutants can reach lakes and rivers?

   Pollutants generally enter lakes and rivers through the following ways:

   - *Pollutants enter waterways indirectly from solid and gaseous wastes.*
   - *Pollutants are carried through ground water to waterways.*
   - *Pollutants are carried through the air from the burning of fossil fuels.*
   - *Pollutants are added directly through waste water.*

2. Define the following terms.

   a. sewage: *liquid and solid wastes which are carried by underground pipes*

   b. effluent: *partially purified waste water which runs into river, lakes, or oceans*

   c. sludge: *the material that settles out of sewage during the primary sewage treatment*

3. Explain what each of the following processes do to waste water.

   a. primary sewage treatment: *done by physical processes. Filtering or sieving is followed by settling.*

   b. secondary sewage treatment: *done by biological processes. The waste water is held in tanks where bacteria and other microorganisms decompose much of the biodegradable waste.*

   c. tertiary sewage treatment: *done by chemical processes. These treatments are designed to remove dissolved nitrates, phosphates, and remaining suspended undissolved solids from the effluent.*

Section 3: Follow-up Activities

Extra Help

1. Which category, vehicle exhausts or industrial processes, is the greatest source of pollution on three of the five graphs?

   Vehicle exhausts are the greatest source of pollution on three of the graphs.

2. Which natural process is found on three of the five graphs?

   Forest fires are the natural process found on three of the graphs.

3. Which of the sources of air pollution is contributed to directly by individuals?

   Vehicle exhaust is contributed to directly by individuals.

4. If there is an immediate danger of extreme air pollution, which would be the easiest solution: reducing vehicle exhaust, or reducing emissions from industrial processes? Why?

   Answers may vary, but most students should answer that restrictions on vehicles would be the easiest.

5. Match the type of pollutant in Column A with the source of pollution in Column B. Place the letter from Column A in the line provided in Column B.

Column A	Column B
a. disease-causing agents	*d* agriculture, forestry, mosquito control
b. carbon compounds	*a* poorly treated domestic sewage
c. water-soluble acids and salts	*b* paper-making plants
d. water-soluble poisons	*g* uranium mining
e. plant nutrients	*e* food-processing industries
f. sediment and suspended undissolved matter	*h* electrical power plants
g. radioactive substances	*c* irrigation
h. heat (from water used as a coolant)	*f* construction

Enrichment

1. Do Checkpoint question 1.

(a)						P	A	R	T	I	C	U	L	A	T	E	S		
(b)			S	U	L	P	H	U	R		O	X	I	D	E				
(c)										A	C	I	D		R	A	I	N	
(d)								P	H	O	S	P	H	A	T	E	S		
(e)												R	E	S	I	D	U	E	
(f)										F	I	L	T	R	A	T	E		
(g)												N	I	T	R	O	G	E	N
(h)									P	R	I	M	A	R	Y				

Hidden word: *tertiary*

Definition: *the level of sewage treatment in which chemicals are used to remove nitrates, phosphates, and remaining suspended solids*

2. Compare the maps shown on pages 309 and 310 of your textbook. One map shows the regions of North America which are the most sensitive to acid rain. The other map shows the regions receiving acid rain. Write a brief paragraph explaining why acid rain may be a more sensitive issue in some parts of Canada than in other parts of the country.

   Answers will vary. Paragraphs should include the information comparing the type of bedrock found in the area with the pH of the rain that is received by that area. Air flow patterns will also dertermine what regions receive acid rain even though they may be some distance away from the source of the pollutants.

Section 3 Assignment

Comment:

For question 1, the textbook question comes from page 328 in *Science Directions 9.*

Marking Guide: Suggested values are given in brackets.

1. Answer question 4 of Checkpoint. Use the table provided on the response page for your answers. (10 marks)

Comment:

When evaluating this question you should be aware that there can be more than one correct answer. The key concepts are that increased plant growth will produce more oxygen; however, as these plants die, decomposition will cause a decrease in oxygen.

Effects of Phosphate Discharge into a Stream

	Increase or Decrease	Reason
(a) water plants and algae	*Increase*	*Phosphate is a fertilizer that stimulates their growth.*
(b) bacteria	*Decrease, then Increase*	*Initially, higher oxygen levels will result in fewer bacteria; however, the presence of decomposing plant materials will eventually allow bacteria to increase.*
(c) dissolved oxygen	*Increase, then Decrease*	*Living plants will cause oxygen levels to increase, decomposing plants will cause oxygen levels to decrease.*

	Increase or Decrease	Reason
(d) insects	*Increase, then Decrease*	*More oxygen will allow insects to increase; decreased oxygen will result in fewer insects.*
(e) fish	*Increase, then Decrease*	*More insects will mean more and bigger fish; however, decomposition of an overabundance of plants and algae may eventually remove all oxygen from the water and the fish will die.*

2. Describe three sources of air pollution that produce acid rain. (5 marks)

   Correct answers may include any of the following:

   - *vehicle exhaust*
   - *burning of sulphur-rich coal*
   - *smelting and metal refining*
   - *burning of sour gas (hydrogen sulphide)*
   - *some industrial air pollution*

Section 4: Water Quality

In this section students will learn more about the sources of wastes in the water supply. Students will also learn how some of the measurements and tests are done to determine the quality of the water. They will make measurements and compare samples by testing for turbidity, phosphates, and disssolved oxygen. Students will learn that these measurements, made in units of milligrams per litre and micrograms per litre, are very small. Students may also begin collecting data which will be of use in a simulated environmental hearing in the last section of this module.

Comment:

Some preparation is needed for Activity 4 and Activity 5 in this section. Refer to these activities for a list of materials and a description of preparation required.

Section 4: Activity 1

1. How is water used in the processing of carrots?

   Large amounts of water must be used to wash the excess soil off of the carrots. In addition, carrots were dipped into a strong solution of lye to loosen the skin. The lye and loose skin then had to be washed off.

2. Describe the technological problem that had to be solved for the carrot-processing industry?

   The problem was how to remove the skins and lye from the carrots without using so much water. A huge amount of water was used to wash the lye from the carrots. This effluent had to be treated before it could be returned to the environment.

3. In what ways are there additional benefits from a technological solution to this problem?

   Carrots retain nutrients that would have otherwise been rinsed away in the water. Ten percent more of the carrot is saved by this process.

4. Play the role of each of the following people being interviewed for a national newsmagazine. Briefly describe the problem and the solution to the potato chip dilemma.

   Answers will vary, sample answers are provided.

   a. potato chip producer:

      "My plant used to cause a lot of waste water which overloaded the city's treatment plant. We now save money by recovering the dried wastes and oil. Our effluent is much cleaner than before."

   b. mayor of the city:

      "Our treatment plant was overloaded and it would be expensive to build a bigger plant. By cooperating with the producer and the farmers, we have saved the jobs at the plant and have saved the taxpayers the cost of upgrading the treatment plant."

   c. local farmer:

      "We are able to buy a cheaper feed for our hog production. This has allowed us to increase profit. At the same time, we have continued to have a market for our potato crop."

Section 4: Activity 2

1. List several ways that you use surface water at least once per week.

   Answers will vary. Students may have given answers such as drinking water, personal cleanliness, and recreation (boating and fishing).

2. a. What is the current population of Rapid Steps?

      The current population of Rapid Steps is 300 000.

b. What will the population of Rapid Steps be in twenty-five years?

In twenty-five years the population will be 600 000.

3. What is the main complaint of the people who live downstream from Rapid Steps?

The drinking water is cloudy and sometimes tastes bad.

4. Why is this a worry for the politicians from Rapid Steps?

Answers will vary. Possible answers include having to answer to evidence that the city is to blame for the problem. Also, installing additional equipment is expensive and taxes will have to increase.

5. Suppose tax money must be used for a cleanup. What are three additional things that tax money is needed for?

Tax money is also required for new sewer pipes, new water pipes, new gas lines, road improvements, school maintenance, and city maintenance.

6. What appear to be the choices of the fertilizer plant?

The fertilizer plant has the choice of cleaning up at a cost that might force them to close down, or having the city do the cleanup for a fee.

7. In what way does the local detergent plant have an interest in this controversy?

If the people of the city used phosphate-free detergent, maybe there would be no need for the expensive changes and the local detergent plant would profit.

8. What is the suggestion of the agriculturalist to solve the dilemma?

The farmers along the river could change their practices and build holding basins to prevent runoff from entering the river.

Section 4: Activity 3

1. Define *turbid.*

   turbid: cloudy or unclear

2. What level of sewage treatment is supposed to remove the suspended solids?

   The secondary treatment is supposed to remove the material which does not settle out.

3. Why was it necessary for the biologist to take samples from a series of sites above and below the sewage treatment plant?

   It is important to know what the water is like prior to the sewage treatment plant. These samples can be used as an experimental control. The changes below the plant may then be attributed to the plant.

4. Do questions 1 and 2 of Analysis.

   Textbook question 1:

   If the particles are larger than the pores in the paper, then the particles will not pass through the paper.

   Textbook question 2:

   Sewage, industrial waste and eroded substances are the sources of the suspended solids.

Comment:

Check to see that your students have recorded the current data for Undissolved Solids from page 324 of the textbook to the table at the end of Activity 2 in their Student Module Booklets.

5. Why does the amount of undissolved solid seem to increase as you go further downstream?

   There are more upstream sources of solids as you move downstream.

6. Why might the amount of undissolved solid be slightly lower at Site 5 than at upstream sites?

   The calmer water here might allow some solids to settle to the bottom. There may also have been a difference in the sampling techniques.

Section 4: Activity 4

Part A is optional, but students must do Part B.

Part A

The following materials and equipment are needed if students are to do Part A.

Caution: The investigation involving phosphate identification for Part A must be done under the supervision of the learning facilitator. You are responsible for the preparation of the chemicals required in this investigation. Read and follow the precautions stated on the labels of the chemical containers.

- safety glasses
- water samples including:
  - distilled water
  - tap water
  - water from a local stream, river, pond, or lake
  - water containing a small amount of phosphate fertilizer
  - water containing a small amount of phosphate detergent
- dilute ammonium hydroxide (household ammonia) solution
- magnesium sulphate (Epsom salts) solution
- five test tubes
- medicine or eye dropper
- graduated cylinder (10 mL)
- watch glass or a glass jar lid
- hand lens

Comment:

The following solutions should be prepared ahead of time in quantities needed for testing by students (15 mL/student).

- Add about 10 g of phosphate fertilizer per one litre of water. A phosphate fertilizer will be designated by a large second number on a fertilizer bag or jar (e.g., 20 – 50 – 20. The number 50 indicates the percentage of phosphorous).

- Add about 10 g or 10 mL of detergent (containing phosphates) per one litre of water.

- Make a magnesium sulphate solution by adding 30 g of Epsom salts per litre of water.

- To make a dilute ammonium hydroxide solution, learning facilitators should purchase a phosphate-free ammonium-based cleaning product, such as generic household ammonia, and make a weak solution by adding one part household ammonia to twenty parts water.

- Distilled water can be obtained by melting ice cubes if no other source is available.

Caution: Ammonium hydroxide is a caustic substance. It can burn your skin. Handle with care. Wear safety glasses, safety gloves, and an apron or lab cover.

1. What is the problem in this investigation?

   How can you determine if phosphates are present in various water samples?

2. List the equipment that is required for safety reasons.

   Safety glasses, safety gloves, and an apron should be worn for safety reasons.

3. Predict which samples will contain phosphates.

   Answers will vary. Students will probably predict that the water containing detergent and the water containing fertilizer will contain phosphates.

4. What is the function of the ammonium hydroxide?

   It is important to make the solution basic to ensure the formation of magnesium phosphate.

5. Do questions 1 to 4 of Analysis.

   Textbook question 1:

   Answers will vary. Water with phosphate fertilizer, water with detergent (if the detergent was not phosphate-free), and river water may all produce a precipitate.

   Textbook question 2:

   The crystals will appear as a white powder.

   Textbook question 3:

   Answers will vary. The answer to this question should confirm student observations of a crystal precipitate forming.

   Textbook question 4:

   The distilled water was an experimental control. No crystals should form in this sample. If crystals do form, then there is something wrong with the test.

Part B

Comment:

No equipment or materials are needed.

6. Do questions 5 and 6 of Further Analysis.

   Textbook question 5:

   Phosphates enter the surface water from sewage or from the runoff from fields which contain fertilizer or manure.

   Textbook question 6:

   It is important to know if the phosphate has been removed from the treated water to determine whether the treatment has been successful.

Comment:

Check to see that your students have recorded the current data for phosphates from page 325 of the textbook to the table at the end of Activity 2 in their Student Module Booklet.

7. Do questions 1 and 2 of Analysis.

   Textbook question 1:

   The largest changes in concentration of phosphates occur between Sites 1 and 2 and between Sites 4 and 5.

   Textbook question 2:

   The greatest source is the sewage plant, since the greatest increase of phosphates was between Site 1 and Site 2. The fertilizer plant and the local farms and ranches also lead to an increase in the phosphates, as indicated by the data results at Sites 3 and 4. It seems that the towns of Springford and Bridgeland did not contribute to phosphate pollution, as the level of phoshates at Site 5 had decreased considerably.

Section 4: Activity 5

Students may do either Part A or Part B.

Part A

The following materials and equipment are needed.

- 100 mL beaker and hot plate or kettle
- tongs or oven mitts
- dissolved-oxygen kit (optional)
- jar with lid

Caution: The investigation involving measuring dissolved oxygen in water for Part A is to be done under the supervision of a learning facilitator. Use a safe set-up for boiling water. A kettle is preferred to ensure students don't spill boiling water on themselves. There are many oxygen testing kits and instruments used by professional biologists. Consult the instructions which accompany the oxygen testing kit that you are using. You should try this activity yourself beforehand so that you are familar with the use of the oxygen testing kit.

Part B

No materials or equipment are needed.

1. Explain the following terms:

   a. abiotic factors: *factors that are non-living parts of the environment*

   b. biotic factors: *factors that are from the living part of the environment*

2. How much oxygen is required in the water to ensure that most organisms that live in the water will be able to live there?

   Most organisms require more than 5 milligrams per litre (5.0 mg/L) of oxygen.

3. Explain what is meant by the units one milligram per litre (1mg/L)

   For every litre of water (solvent) there is a milligram of the material (solute). In this case the solute is oxygen.

4. Record your data in the following table.

   Answers will vary. Compare your data to the results provided in question 5.

5. Examine the information provided in the Appendix. Record the appropriate data in the table provided in question 4 of Part A.

   The data represents the average oxygen content of three water samples in the following situations:

Sample	Dissolved Oxygen (mg/L)
1. tap water	*varies 6 – 10*
2. boiled water	*zero*
3. boiled, cooled water	*zero*
4. sample 3, shaken	*varies 2 – 6*
5. sample 3, shaken again	*varies 4 – 8*
6. sample 3, shaken third time	*varies 6 – 10*

6. Do question 2 of Analysis on page 327 of your textbook.

   The higher the temperature, the less dissolved oxygen it can hold.

7. Write a statement to describe the effect of increased turbulence on the oxygen content of water.

   Increased turbulence increases the oxygen content of the water.

8. Do questions 4 and 5 of Further Analysis.

   Textbook question 4. (a):

   This question could be answered in several ways. The student might indicate the season of the year, or the temperature of a specific day as something that would change the water temperature. Large factories may discharge warm effluent into the river. If the speed of the running water is slowed down by something like a dam, the water will be warmed by the sun.

   Textbook question 4. (b):

   As the water warms up, some of the animals may die because of a decrease in the dissolved oxygen content.

Textbook question 5:

Rapids, waterfalls, or even some large rocks in the water will help to oxygenate the water. Water plants and algae are the most important sources of oxygen. They release oxygen during photosynthesis.

Comment:

Check to see that your students have recorded the current data for dissolved oxygen from page 327 of the textbook to the table at the end of Activity 2 in their Sudent Module Booklet.

9. Do questions 1 and 2 of Analysis.

   Textbook question 1:

   The oxygen concentration shows a decrease at Sites 2, 3, and 4.

   Textbook question 2:

   The most likely source of pollution is the sewage treatment plant which discharges biodegradable sewage into the river. As the sewage decomposes, oxygen is used up. To a lesser extent, the fertilizer plant and the farms and ranches are also sources of pollution responsible for the decrease in the dissolved oxygen content in the Rapid River.

Section 4: Follow-up Activities

Extra Help

1. What happens to the carbon dioxide dissolved in pop when the drink is heated up and allowed to go flat?

   The carbon dioxide escapes into the air.

2. Do you think that it is easier to dissolve a gas in warm or cold water?

   It is easier to dissolve a gas in cold water.

3. What happens to the dissolved oxygen as you heat water to boiling?

   The oxygen escapes into the air.

4. Describe one way that oxygen could be lost from water in streams and rivers.

   If the water warms up or if there is an increase in the amount of biodegradable solids in the water, the amount of dissolved oxygen will decrease.

5. Describe one way that oxygen could be returned to the rivers and streams.

   Answers will vary. Increased turbulence will add some oxygen, but the greatest contribution is made by water plants and algae that produce oxygen during photosynthesis. However, too many plants or too much algae is also dangerous. They will decompose after they die and this will remove oxygen from the water.

Enrichment

Find an article in a newspaper or a magazine which describes some positive steps taken by an industry to improve the environment by reducing the amount of wastes distributed to the air or water. Write a short paragraph which describes the major issues and how the company tackled the problem.

Answers will vary. Ask the student to explain why the actions taken are positive steps.

Section 4 Assignment

Marking Guide: Suggested values are given in brackets.

1. a. List two abiotic factors and two biotic factors that determine the level of oxygen in a stream or river. (2 marks)

      abiotic factors: temperature of water and turbulence

      biotic factors: green plants and algae, animals, amount of decomposing organic material

   b. Explain how each of the factors listed in question 1 affects the oxygen level. (4 marks)

      temperature: water holds less oxygen at higher temperatures

      turbulence: increases the amount of dissolved oxygen

      green plants and algae: produce oxygen during photosynthesis

      animals: consume oxygen during respiration

      decomposing organic material: consumes oxygen

Comment:

For question 2, the textbook question comes from page 328 in *Science Directions 9*.

2. Answer question 6 of Checkpoint.

   Textbook question 6. (a): (2 marks)

   Answers may include the following:

   - *poor sewage treatment*
   - *soil erosion*
   - *disturbance of a stream bottom by vehicles (boats)*
   - *release of water from a dam*
   - *industrial waste*

   Textbook question 6. (b): (2 marks)

   Photosynthesis may be reduced because sunlight is unable to penetrate as far into the water. This will reduce the amount of oxygen produced by plants, and they will have to consume oxygen in order to survive.

Section 5: Living Indicators of Water Quality

In this section students learn to recognize some of the organisms used to indicate water quality. They will learn sampling techniques used by aquatic biologists. An opportunity is provided for students to study an actual sample of water collected previously or a sample collected by the student from a local stream.

If it is not possible for students to conduct an actual field study, a print pathway is provided.

Section 5: Activity 1

1. What is a general rule about the number of organisms and the cleanliness of the water?

   Water that is polluted will generally have fewer kinds of organisms than similar amounts of clean water.

2. What is meant by the term *biological indicator*?

   This is a living organism which can be used to give information about the environment.

3. Explain in your own words how biological indicators are used.

   Answers will vary. Sample answer: It is possible to use certain organisms as biological indicator because they will grow only in water with an adequate amount of oxygen.

4. Do you think that the data obtained from biological indicators is more or less reliable than the data obtained from chemical tests? Give reasons for your opinion.

   Answers will vary. Students may argue that a chemical indicator is more accurate because the standards can be repeated, or that the biological indicators may be unreliable because other factors may influence their tolerance in that environment.

Section 5: Activity 2

Students may do either Part A or Part B.

Comment:

The preferred pathway for this activity is Part A, involving the collection of organisms from a pond or stream. However, this can only be done during a suitable time of year and requires the equipment listed. If this option is not possible, students may do Part B.

Caution: Part A is to be done under the supervision of a learning facilitator.

Part A

The following equipment and materials are needed:

- net with metal rim
- appropriate clothes (such as rubber boots or waders)
- shovel
- dissolved oxygen kit
- container with lid
- petri dish
- hand lens or dissecting microscope
- 70% ethanol solution (optional)

Part B

No equipment or materials are needed.

Comment:

Data will vary depending on the time of year and the location of the sample. If you collect organisms different from those listed, try grouping similar organisms and obtain a total for each group.

1. Do questions 1 to 5 of Analysis in Part A on page 333 of your text.

   Textbook question 1:

   Answers will vary. Compare your results with those in Table 6-5 on page 330 of Science Directions 9.

   Textbook question 2:

   Answers will vary, but there should be a correlation with the answer obtained with the dissolved oxygen kit.

   Textbook question 3:

   If the two answers are not in agreement, the variation is most likely in the counting and classification of the organisms.

   Textbook question 4:

   Answers may vary, depending on the sample.

   Textbook question 5:

   Sources of error can be in both the chemical indicator and in the biological indicators. The identification of the insect larvae probably represents the greatest source of error for students.

2. Describe how you would collect and preserve a sample of invertebrates from the bottom of a river or stream.

   - *Use a net and a shovel to scoop organisms from the bottom after stirring up the mud.*

   - *Store the organisms in a bucket of fresh water from the stream.*

   - *If you are unable to examine the organisms for 24 hours or more, preserve them in a 70% ethanol solution.*

3. Describe how you would analyse your sample to provide data on water quality.

   - *Place a sample of the water in a petri dish.*
   - *Examine and identify the types of organisms present.*
   - *Count the number of each type of organism and tabulate your data.*

4. Examine the data from Site 1 on Table 6-7 on page 333 of your textbook and make a statement about the water quality at this site.

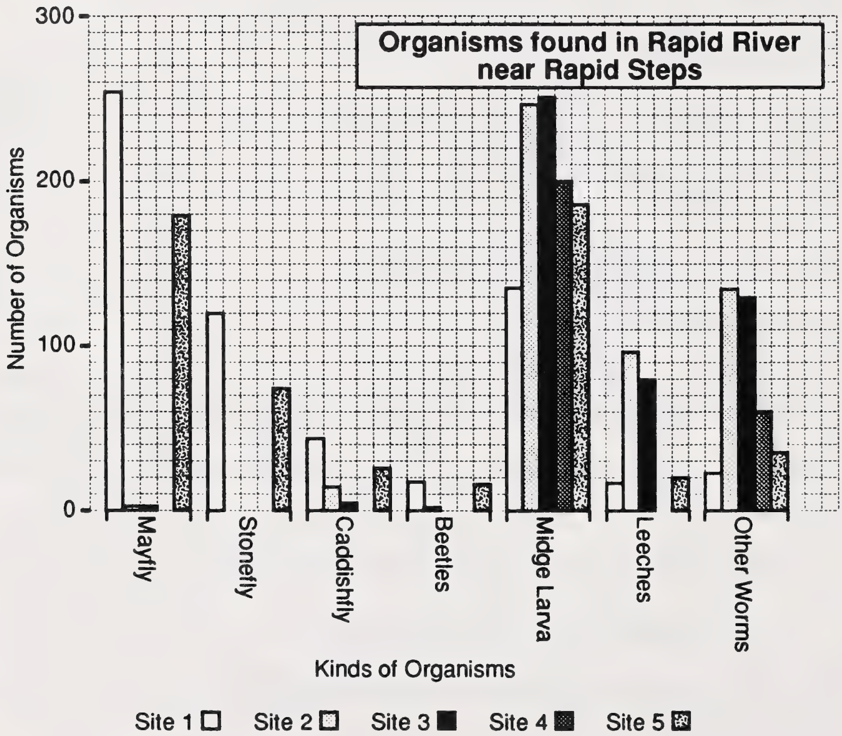
   The presence of a large number of beetles and a variety of fly larvae indicates excellent oxygen levels.

5. Answer questions 1 to 5 of Analysis in Part B.

   Textbook question 1:

   Comment:

   There are other ways in which this graph may be plotted. This is presented as a sample solution only.



   Textbook question 2:

   The loss of midges and the gain of worms indicates that there must be a decrease in dissolved oxygen content.

Textbook question 3:

As the dissolved oxygen content changes, so do the amounts and kinds of different organisms.

Textbook question 4:

Yes, there is a correlation.

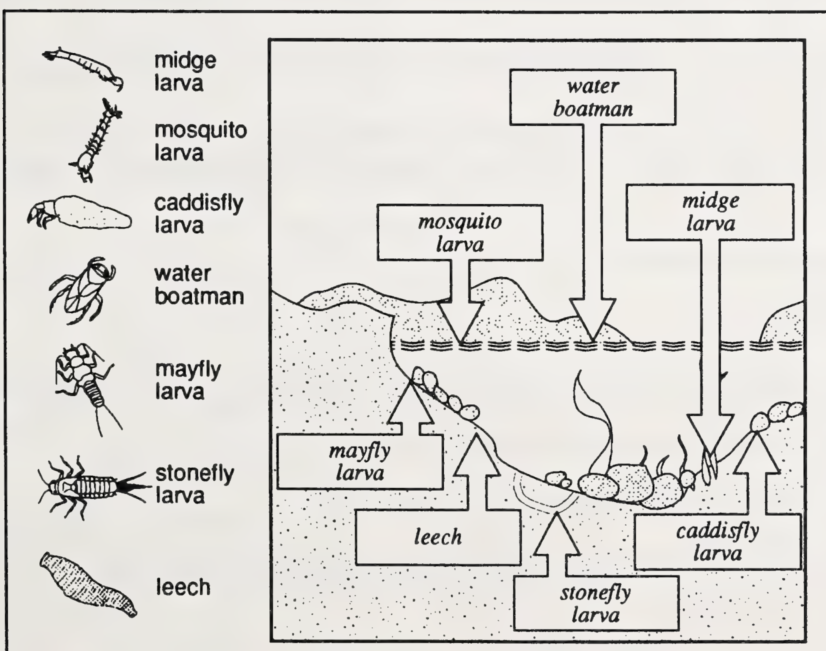
Textbook question 5:

Dissolved oxygen is in the excellent range at Site 1. Below the sewage treatment plant, there is a definite drop in dissolved oxygen. This drop continues past the fertilizer plant. There is also an indication that there is a loss of dissolved oxygen due to the farm runoff. At Site 5 there is an increase in dissolved oxygen content, which may result from the water entering the river from the stream at Bridgeland or increased plant growth below the fertilizer plant.

Section 5: Follow-up Activities

Extra Help

1. Match the organisms on the left with their habitats on the right. Write the names in the appropriate locations.



2. Three students were hiking through the forest when they discovered a small pond. One of the students picked up a rock and discovered a large number of leeches under it. They concluded that the oxygen concentration must be very low. However, one of the students suggested that they must also look to see if there were any Caddisfly larvae or Mayfly larvae in the water before deciding for sure.

   Explain why it is a good idea to check for Caddisfly larvae and Mayfly larvae first.

   Leeches will grow where there is a high dissolved oxygen content or where there is a low dissolved oxygen content. If there are about ten times as many Caddisfly larvae or Mayfly larvae than there is leeches, then the dissolved oxygen is content excellent. If there are no Caddisfly larvae or Mayfly larvae then the dissolved oxygen content could be low or very low. One organism by itself cannot be an indicator.

Enrichment

Comment:

For questions 1 and 2, the textbook questions come from page 333 in *Science Directions 9*.

1. Answer question 6 of Extension.

   Answers will vary greatly, depending on the organism chosen. However, all insects will go through a metamorphosis which should be noted in the description.

2. Answer question 7 of Extension.

   Answers will vary. The answer to this should include the method that the organism uses to increase the surface area for exchange and/or the flow of water over the surface.

Section 5 Assignment

Comment:

For questions 1 to 3, the textbook questions come from page 339 in *Science Directions 9*.

Marking Guide: Suggested values are given in brackets.

1. Answer question 1 of Checkpoint. (2 marks)

   Large numbers of mayfly larvae signify that the dissolved oxygen content is excellent.

2. Answer question 2 of Checkpoint. (4 marks)

   Textbook question 2. (a):

   leeches

   Textbook question 2. (b):

   Water quality is low.

3. Answer question 3 of Checkpoint. (4 marks)

   Worms would be most numerous downstream of a sewage treatment plant because the oxygen level is low due to decomposition of sewage.

Section 6: An Environmental Hearing

Throughout this module the students collected scientific data about Rapid River. In their readings students found that there were many different concerns expressed. In this section students will consider the different viewpoints that are expressed about Rapid River. Students will then prepare to take part in a public hearing which examines the issues before the Rapid Steps city council.

Section 6: Activity 1

1. After reading the viewpoints that are presented on pages 334 and 335 of your textbook, complete the following table.

Role	For/Against/ Neutral	Viewpoint	Summary of Reasons
city taxpayer	*against*	*egocentric/economic*	*Taxes are high already. We pay to clean water; other communities should pay too.*
city council member	*against*	*economic/political*	*Money is needed elsewhere. Who would vote for raised taxes?*
manager of detergent factory	*against*	*economic*	*Phosphate-free detergent would help solve the problem.*
worker from plant	*for*	*economic*	*That is where I can find a job.*

Role	For/Against/ Neutral	Viewpoint	Summary of Reasons
manager of fertilizer plant	*for*	*economic*	*If city does it, we can use the upgrade and save doing it ourselves.*
representative for towns of Bridgeland and Springford	*for*	*egocentric/economic*	*Our small towns cannot afford to clean up after you. Our water tastes bad and it's your fault.*
sewage treatment technologist	*neutral*	*scientific*	*It can be done, but it is expensive.*
agricultural researcher	*neutral*	*scientific*	*Phosphates and nitrates come from agricultural sources, also. These can be cleaned up in other ways.*
local teacher	*for*	*recreational*	*The river is not what it used to be 10 years ago.*
member of local environmental group	*for*	*ecological*	*We must keep the river safe for all species.*
fishing guide	*for*	*economic/recreational*	*I don't get as many fishing parties as I used to.*
freshwater biologist	*against*	*scientific*	*These are the results of water analysis.*
farmer/rancher	*for/neutral*	*egocentric/economic*	*It is easier for the city to clean up than for individual farmers/ranchers to change.*

2. Develop three to five questions that you could ask the participants in the environmental hearing. The questions may be general and addressed to all participants, or the questions may be very specific and addressed to one person. Indicate who should answer each question (e.g., To: all participants, or To: the fishing guide).

   Answers will vary. Sample answers:

   To: *manager of detergent factory*

   Question: *Does your manufacturing process create any additional wastes if you make more of your product?*

   To: *sewage treatment technologist*

   Question: *What happens to the aluminum sulphate or magnesium sulphate? Doesn't that lead to pollution as well?*

   To: *fishing guide*

   Question: *Why don't you just move upstream from the city?*

Section 6: Activity 2

1. Which role have you chosen to prepare for?

   Answers will vary. The learning facilitator should be looking for the student to be consistent in all subsequent answers.

2. Are you for, against, or neutral about spending tax money on this project?

   Answers will vary but should justify the viewpoint chosen.

3. Write your speech for the hearing. The speech must be approximately two minutes in length. Practise giving this speech in the role you have chosen. To be convincing, ensure that your timing is right!

Comment:

Look for the student to begin the speech by stating the position clearly. The student should then support the position with facts gathered both from experiments and from researched articles.

The students should know enough about the topics so that they can answer any question that you may ask them after the speech. The learning facilitator can aid in making this a more realistic role play for the students by asking questions from a different point of view.

Comment:

For questions 4 and 5, the textbook questions come from page 337 in *Science Directions 9*.

4. Do questions 1, 4. (a), and 4. (b) of Analysis on page 337 of your text.

   Textbook question 1:

   Answers will vary. The answer must be consistent with the previous student answers in this section.

   Textbook question 4. (a):

   The city is the greatest source, but the fertilizer plant and the farms and ranches also contribute to the phosphate pollution problem.

   Textbook question 4. (b):

   Answers will vary. Sample answer:

   The city must spend the money to upgrade the sewage treatment plant.

5. Do questions 5, 6, 7, 8, 9, and 10. (b) of Further Analysis on page 337 of your text.

   Textbook question 5:

   Individuals can make a difference if they participate in the process in a meaningful way. Individuals can also work with others to form interest groups with greater influence.

   Textbook question 6:

   The main point of student paragraphs should be that science played a role by providing the data on which the decision was based.

   Textbook questions 7 and 8:

   Answers will vary. The purpose of these questions is to show the types of evaluations that must be made with any possible solution.

Textbook question 9:

Answers will vary. It is possible that the student might alter the original decision after considering these additional consequences and their importance.

Textbook question 10. (b):

Answers will vary. Sample answer:

Phosphate-free detergent could be the only detergent sold in the stores.

6. How effective was the decision-making process you used?

   The student should appreciate that decisions regarding environmental quality are needed, and that the process should be informed by knowledge of environments and objective assessments of environmental impacts.

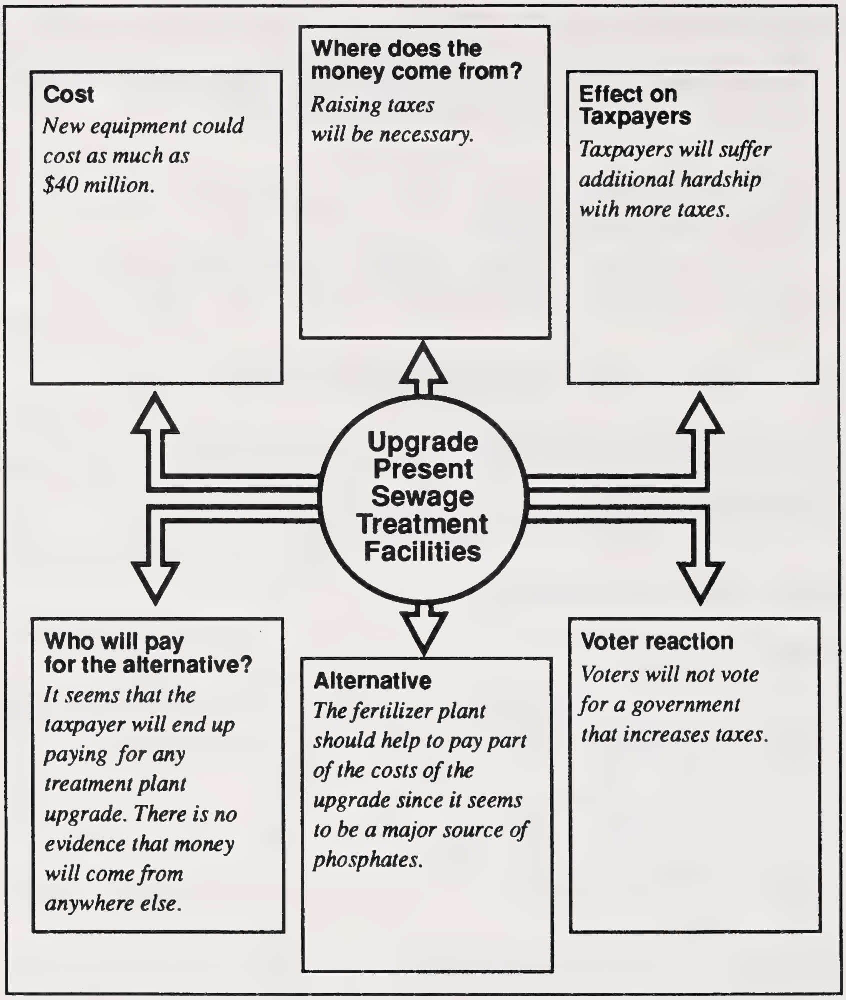
Section 6: Follow-up Activities

Extra Help

1. Take the role of a city council member and cluster ideas for your presentation. Indicate the point in the labelled circle.

   Answers will vary. Sample answers:

   The diagram appears on the next page.



2. Prepare a two minute presentation by organizing your ideas from the previous question.

Answers will vary. Students should now take the ideas clustered in the previous question and combine them into a paragraph.

Enrichment

Students may do either Part A or Part B.

Part A

1. Determine the issue.

   Answers will vary.

2. What major viewpoints are expressed?

   Answers will vary. Look for a statement of a problem or a comparison of two points of view.

3. What evidence is there that science has played a role in this hearing?

   Answers will vary. Students should recognize the importance of science in the gathering of data and the evaluation of solutions.

Part B

Attend a local public environmental hearing.

4. Take the role of a reporter and prepare a news report on what you learned at the hearing. Include the following necessary information:

   - What is the issue?
   - What are some of the viewpoints?
   - How is science playing a role in the societal decision?

   Answers will vary.

Final Module Assignment

Comment:

For questions 1 and 2, the textbook questions come from page 339 in *Science Directions 9*.

Marking Guide: Suggested values are given in brackets.

1. Answer question 4 of Checkpoint.

   Textbook question 4. (a): (2 marks)

   It will become an issue when some people see the sawmill as an opportunity for economic growth, while other people see it as a contributor to environmental damage.

Textbook question 4. (b): (2 marks each – 10 marks)

Answers will vary. Possible answers include the following:

ecological: A sawmill will cause environmental problems in the long run. The plant must be built so that it does not cause pollution.

economic: A sawmill will bring many jobs into the area.

educational: A sawmill will provide an opportunity for a forestry school or demonstration forest.

egocentric: The ranchers do not want their quality of life reduced. A sawmill will ruin the peace and quiet of the neighbouring properties.

ethical/moral: Are the trees better left for nature? Do we really need this mill?

health-related: Checks must be run to see that the plant will not add chemicals to the air.

recreational: The logged areas will not be as beautiful as it was before; wild-life habits will be changed and the fish populations in the river may be harmed by increased runoff.

political: Politicians may be able to gain votes if they have attracted a new employer to the area.

scientific: Studies must be done on the river to determine if the area is sensitive to such a change, or to act as a control for later studies.

technological: The sawmill technology must be proven safe.

2. Answer question 5. (b) and 5. (c) of Checkpoint.

   Textbook question 5. (b): (4 marks)

   The water quality is good at Site A, but at Site B there is an immediate and serious drop in quality. After Site C, there is a small recovery in part because of the side stream. After Site D, the river seems to have recovered partially. The ranch may have contributed organic matter that decomposes to cause the oxygen depletion that killed Alice Gunning's fish.

   Textbook question 5. (c): (4 marks)

   The situation should be studied further to determine the exact source of the pollution. There are laws against poor waste management and polluters will be forced to clean up their act. Drainage may have to be corrected, settling ponds built, and the source of waste material reduced or controlled.

Comment:

At this point your student(s) may do Part A, using the articles collected about a particular environmental issue, or they may do Part B if they prefer to answer questions from their textbook.

3. Use information from articles that you collected to help you prepare a one page report about an environmental issue. Your essay should consist of five short paragraphs that provide answers to the following questions. (20 marks)

    - What is the issue?
    - Describe two or more opposing points of view on the issue.
    - How might science help to resolve this issue?
    - What is a possible solution to this issue?
    - How could science be used to evaluate your solution?

Comment:

Students should prepare their reports in essay form. When marking student reports be sure that they have included information that answers the questions above.

Comment:

For questions 4 to 7, the textbook questions come from page 341 in *Science Directions 9*.

4. Answer question 7 of Backtrack. (5 marks)

    - *At location 1 smoke containing small amounts of sulphur dioxide is carried high into the atmosphere.*

    - *At location 2 automobile exhaust releases nitrogen dioxide into the air.*

    - *At location 3 these gases (sulphur dioxide and nitrogen dioxide) dissolve in water to form dilute sulphuric acid and nitric acid.*

    - *At location 4 precipitation falls as acidic rain or snow. This water can then dissolve heavy metals from minerals.*

    - *At location 5 the water accumulates in lakes. As the pH rises the number and variety of organisms decreases.*

5. Answer question 8 of Synthesizer. (4 marks)

    The manufacturers are responsible for producing a safe product. The public cannot be held responsible for disposal of potentially toxic waste that requires special handling and disposal. Improper disposal present a danger to the public.

6. Answer question 9 of Synthesizer. (6 marks)

   Answers will vary. Accept reasonable answers that reflect alternatives to the automobile.

7. Answer question 11 of Synthesizer. (5 marks)

   Answers will vary. Sample answers include:

   Textbook question 11. (a):

   increased cost of electricity

   Textbook question 11. (b):

   lower household temperatures in winter

   Textbook question 11. (c):

   increased use of public transport

   Textbook question 11. (d):

   pollution will simply become more dilute and widespread

   Textbook question 11. (e):

   higher energy costs for plant conversion and increased demand for a single resource

Final Test

There are two copies of the final test: the teacher's copy which includes a marking guide, and the student's copy which is perforated and designed for photocopying and possible faxing.

Note:

The student's copy and the teacher's copy of this final test should be kept secure by the teacher. Students should not have access to this test until it is assigned in a supervised situation. The answers should be stored securely and retained by the teacher at all times.

SCIENCE 9

FINAL TEST

GENERAL INSTRUCTIONS

YOU HAVE **TWO** HOURS TO COMPLETE THIS TEST. Work quickly through the complete exam, first concentrating on the questions you are sure you know. Then answer the more difficult questions in the time remaining.

TOTAL MARKS: 100

PART A:	Multiple-Choice Questions	58 marks
PART B:	Written-Response Questions	42 marks

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Value

PART A: MULTIPLE-CHOICE QUESTIONS

58 All multiple-choice questions must be answered on the Part A Response Page included in your test.

Read each question carefully and decide which of the choices BEST completes the statement or answers the question. Locate the question number on the Response Page and fill in the space that correspondes to your choice.

1 each

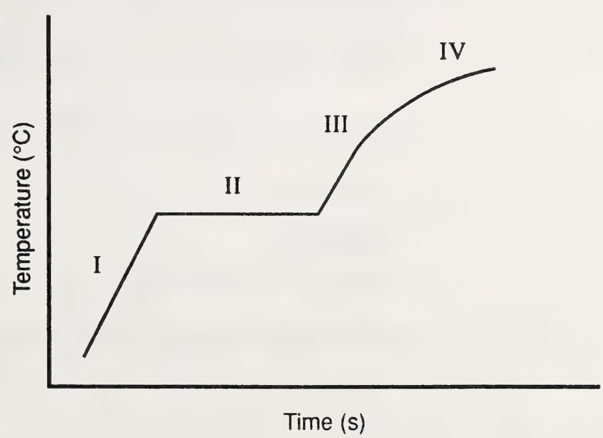
B 1. If you think that an unknown liquid contains water, which of the following chemicals should you use to check your suspicion?

A. copper (II) sulphate
B. cobalt (II) chloride
C. carbon dioxide
D. limewater

A 2. Which of the symbols below indicates that the solution is corrosive?

A. B. C. D.

B 3. The region on the graph which indicates the melting point of a crystal is



A. I
B. II
C. III
D. IV

TEACHER'S COPY

C 4. When you put 25 g of a solid into 50 mL of warm water, it all dissolved, but when you tried to put an additional 5 g into the water, 3 g that would not dissolve were left. The solubility of the solid is

A. 25 g/100 mL
B. 27 g/100 mL
C. 54 g/100 mL
D. 56 g/100 mL

D 5. Which of the following is a chemical change?

A. water evaporating
B. salt dissolving
C. wax melting
D. coal burning

D 6. Placing lead (II) nitrate solution into a flask of potassium iodide solution results in the formation of a(n)

A. liquid
B. element
C. homogeneous mixture
D. precipitate

C 7. Tomato juice has a pH of 4.2. Human blood has a pH of 7.4. Which of the following is true?

A. Both tomato juice and human blood could be considered neutral.
B. Tomato juice and human blood are both bases.
C. Tomato juice is acidic, human blood is basic.
D. Human blood is acidic, tomato juice is basic.

C 8. Which of the following is a property of an acid?

A. tastes bitter
B. feels slippery
C. tastes sour
D. turns red litmus paper blue

D 9. A pH level which indicates a basic substance is

A. 2.7
B. 4.8
C. 7.0
D. 9.4

C 10. An oxidation reaction has occurred in which of the following examples?

A. An ice cube disappears in a glass by the sink.
B. An instant pudding gels in the fridge.
C. A white powder forms on an old car as the paint fades.
D. A stain disappears when treated with a powerful cleaner.

B 11. Which of the following substances is highly compressible?

A. water
B. air
C. vegetable oil
D. glycerol

B 12. Liquids and gases are considered fluids because they

A. have indefinite shape
B. flow
C. don't freeze
D. have small spaces between their particles

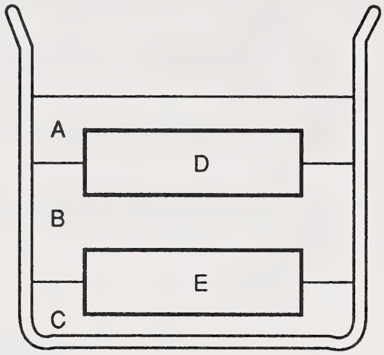
C 13. It is said that oil is more viscous than water because it

A. flows more quickly than water
B. is thinner than water
C. is more resistant to flow than water
D. is less resistant to flow than water

A 14. The best way to make molasses flow more quickly is to

A. heat it up
B. cool it down
C. stir it gently
D. shake it

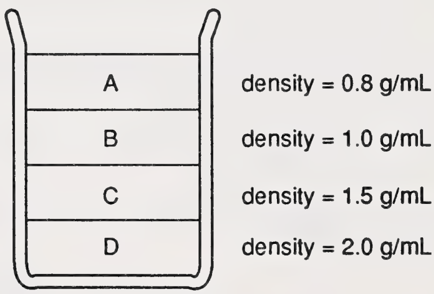
C 15. Three liquids and two solids are placed in a beaker and are separated as shown in the diagram.



Which of the following statements is true?

A. Solid D is more dense than solid E.
B. Liquid B is more dense than solid E.
C. Solid E is more dense than liquid A.
D. Liquid A is more dense than solid D.

C 16. You put four liquids in a graduated cylinder with densities as listed below.



If an object with a density of 1.2 g/mL is dropped into the cylinder, it will settle

A. on top of liquid A
B. between liquids A and B
C. between liquids B and C
D. between liquids C and D

_D_ 17. A sample of gold was placed in beakers of oil, mercury, water, and alcohol. It sank to the bottom in each case. Using a copper sample, it sank in all liquids except mercury. Which of the statements is a possible conclusion for this experiment?

A. Alcohol has a density less than water.
B. Oil has a density less than oil.
C. Copper has a density greater than mercury.
D. Gold has a density greater than copper.

_B_ 18. A reasonable measurement of the air pressure today would be

A. 1000 kPa
B. 100 kPa
C. 1.0 kPa
D. 10 kPa

_D_ 19. The reason that a block of cement loses weight as it is lowered into water is because

A. it is losing mass
B. it is denser than the water
C. the water is a liquid
D. of the buoyant force of water

_A_ 20. A hydrometer measures

A. density of liquids
B. displacement of liquids
C. density of solids
D. pressure of liquids

_C_ 21. The pressure under a liquid depends on

A. the weight and the density of the liquid
B. the depth and volume of the liquid
C. the density and depth of the liquid
D. the mass and density of the liquid

_C_ 22. The pressure inside a hydraulic press is

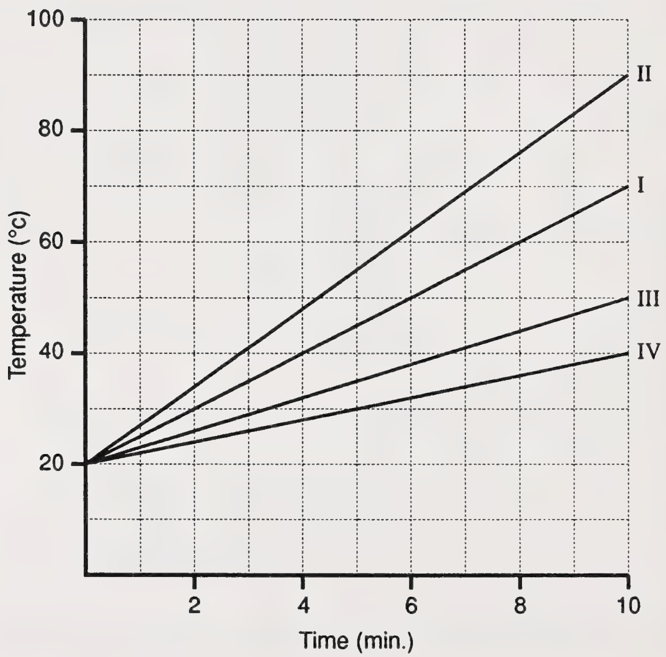
A. higher at the smaller piston
B. higher at the larger piston
C. the same throughout the system
D. lower at the small piston

D 23. The SI unit for quantity of heat is the

A. degree Celsius
B. Kelvin
C. calorie
D. joule

D 24. A heater produces 10 J of heat per minute. It is used to heat 100 g samples of four different substances. The results of each heating session are provided in the graph. The substance in the graph which has the highest heat capacity is labelled

A. I
B. II
C. III
D. IV



B 25. Poor conductors of heat can be used for

A. bottoms on pots and pans
B. handles on cooking utensils
C. radiators
D. reducing friction

B 26. A substance which is a poor conductor of heat is

A. magnesium
B. wood
C. iron
D. silver

B 27. Substance A has a temperature of 15°C. Substance B has a temperature of 25°C. If the two substances were brought into close contact, heat would

A. move from Substance A to Substance B
B. move from Substance B to Substance A
C. move in both directions
D. not move in either direction

C 28. When 10 mL of water at a temperature of 35°C is poured into a beaker containing 100 mL of water at 80°C, the mixture will have a temperature

A. slightly lower than 35°C
B. slightly higher than 35°C
C. slightly lower than 80°C
D. slightly higher than 80°C

D 29. In a solar water heater, water runs through pipes that are exposed to sunlight. The best material for the pipes would be

A. light in colour and a good insulator
B. light in colour and a good heat conductor
C. dark in colour and a good insulator
D. dark in colour and a good heat conductor

A 30. The part of a solar heating system that provides a place to keep heat for use at night and when it is cloudy is the

A. heat storage device
B. collector
C. air-water heat exchanger
D. pump

B 31. Current electricity moves best through

A. plastic
B. copper
C. nichrome
D. rubber

A 32. A galvanometer is a device that

A. detects electrical current
B. measures the voltage of a battery
C. measures the resistance of a load
D. detects the pressure of the electrical flow

A 33. Current is measured in

A. amperes
B. volts
C. ohms
D. neutrons

B 34. The piezoelectric effect demonstrates electrical energy being produced from

A. mechanical energy
B. sound energy
C. light energy
D. chemical energy

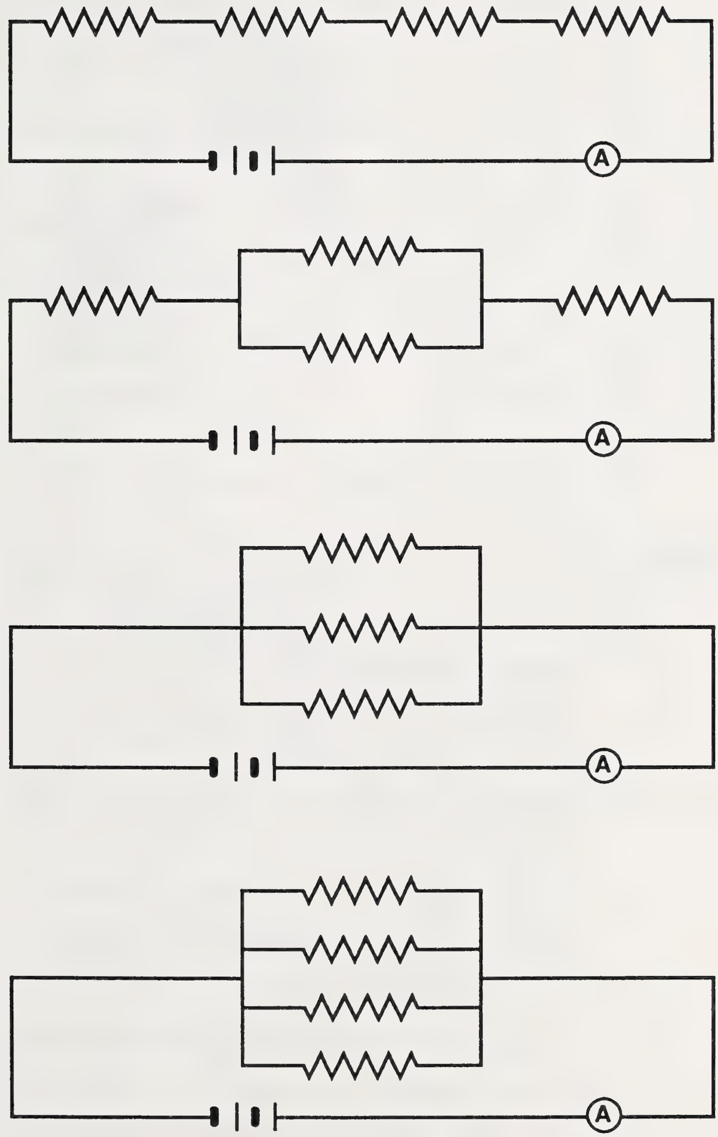
D 35. Which of the following parts could be used to make a working electrical cell?

A. zinc and copper electrodes and tap water
B. two zinc electrodes and tap water
C. two copper electrodes and salt water
D. zinc and copper electrodes and salt water

C 36. A light bulb is connected to a battery. What happens to this light bulb when a second light bulb is hooked in series with it?

A. The first bulb keeps the same brightness.
B. The first bulb becomes brighter.
C. The first bulb becomes dimmer.
D. The first bulb burns out immediately.

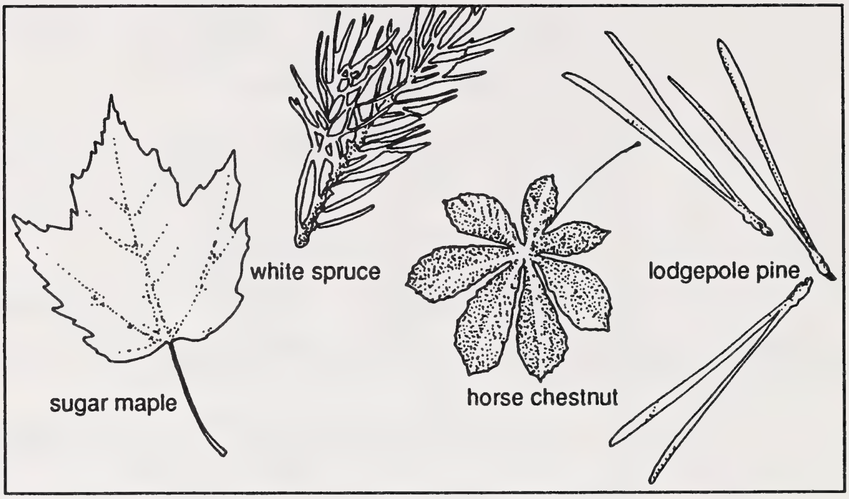
D 37. In the circuits shown, the resistors have the same resistance and the batteries have the same voltages.



In which circuit will the ammeter reading be the highest?

A. I
B. II
C. III
D. IV

Use the pictures of the leaves and the dichotomous key to answer questions 38, 39, and 40.



Dichotomous Key		
#1.	Leaves are needle shaped	go to #2
	Leaves are not needle shaped	go to #5
#2.	Needles attached in bundles	go to #3
	Needles not attached in bundles	go to #4
#3.	Needle leaves are short	Type A
	Needle leaves are long	Type B
#4.	Needle leaves are short	Type C
	Needle leaves are not short	Type D
#5.	Leaves are simple	go to #6
	Leaves are made up of many leaflets	go to #7
#6.	Leaves are notched greatly	Type E
	Leaves are not notched greatly	Type F
#7.	Leaflets extending from the centre	go to #8
	Leaflets not extending from the centre	go to #9
#8.	Leaf consists of three or less leaflets	Type G
	Leaf consists of three or more leaflets	Type H
#9.	Leaf consists of three or less leaflets	Type I
	Leaf consists of three or more leaflets	Type J

_C_ 38. The horse chestnut leaf could be identified as

A. Type E
B. Type F
C. Type H
D. Type J

_C_ 39. The white spruce leaf could be identified as

A. Type A
B. Type B
C. Type C
D. Type E

_B_ 40. The sugar maple leaf could be identified as

A. Type C
B. Type F
C. Type G
D. Type I

_D_ 41. A fish with a mouth that faces upward and that is streamlined for swimming is likely a

A. slow swimming bottom feeder
B. fast swimming bottom feeder
C. slow swimming surface feeder
D. fast swimming surface feeder

_C_ 42. The Linnaean classification system organizes living things into seven categories. In order from the most general to the most specific, they are

A. Kingdom, class, phylum, order, family, genus, species
B. Species, genus, family, order, phylum, class, kingdom
C. Kingdom, phylum, class, order, family, genus, species
D. species, genus, family, order, class, phylum, kingdom

_D_ 43. The phylum Arthopoda is made up of animals with

A. tube feet
B. gills for breathing when they are young
C. worm-like bodies
D. exoskeletons and jointed limbs

D 44. The phylum Gymnosperms include

A. ferns and mosses
B. tulips and oak trees
C. pine trees and apple trees
D. spruce and pine trees

C 45. The major kingdoms of living things are

A. Prokaryotae, Fungi, Mammalia, Chordata, Plantae
B. Prokaryotae, Plantae, Cnidarians, Animalia, Protists
C. Animalia, Plantae, Fungi, Protista, Monera.
D. Animalia, Plantae, Fungi, Chordata, Protista

A 46. Termites cannot digest the wood fibers themselves, but inside their bodies lives a microorganism that digests the wood fibers for them. Both animals benefit each other. This is an example of

A. mutualism
B. mimicry
C. camouflage
D. a predator and prey relationship

B 47. One cause of the greenhouse effect is

A. increased ultraviolet light
B. increased amounts of carbon dioxide emissions
C. evaporation of the world's oceans
D. increased plant growth in northern regions

B 48. Waste would best be defined as anything that is

A. garbage
B. useless
C. discarded
D. causing pollution

D 49. The discovery that microorganisms lead to diseases helped increase the population because

A. more sanitary conditions were developed
B. improved medical treatments were developed
C. food production was improved
D. all of the above

_C_ 50. If a person expresses the phrase "Not in my back yard", that person is expressing the

A. ecological viewpoint
B. economic viewpoint
C. egocentric viewpoint
D. ethical/moral viewpoint

_A_ 51. A waste material which can be used as food by microorganisms such as bacteria and fungi is called

A. biodegradable
B. non-biodegradable
C. abiotic
D. biotic

_D_ 52. A factor that is part of the living environment is called

A. biodegradable
B. non-biodegradable
C. abiotic
D. biotic

_C_ 53. Acid rain is produced because

A. carbon dioxide is produced in combustion
B. automobile exhaust contains many particulates
C. industrial processes produce nitrogen oxides as wastes
D. carbon monoxide is produced in major forest fires

_A_ 54. Primary sewage treatment will remove most of the

A. suspended solids
B. biodegradable wastes
C. phosphates
D. nitrates

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A. secondary sewage treatment
B. tertiary sewage treatment
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D. secondary and tertiary treatment

A 56. Water which contains a large variety of invertebrates has an oxygen content which is considered to be

A. excellent
B. good
C. critical
D. low

B 57. Water which contains a few mayfly larvae, but many midge larvae has an oxygen content which is considered to be

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D 58. Mary was checking the water quality of the Bow River. She obtained a partially filled test tube of river water. She added 20 drops of dilute ammonium hydroxide and a few millilitres of magnesium sulphate to the contents of the test tube. A precipitate formed. What pollutant is likely present in the water?

A. sulphuric acid
B. bacteria
C. radioactive wastes
D. phosphates

PART A: RESPONSE PAGE

B	1.	C	21.	D	41.
A	2.	C	22.	C	42.
B	3.	D	23.	D	43.
C	4.	D	24.	D	44.
D	5.	B	25.	C	45.
D	6.	B	26.	A	46.
C	7.	B	27.	B	47.
C	8.	C	28.	B	48.
D	9.	D	29.	D	49.
C	10.	A	30.	C	50.
B	11.	B	31.	A	51.
B	12.	A	32.	D	52.
C	13.	A	33.	C	53.
A	14.	B	34.	A	54.
C	15.	D	35.	B	55.
C	16.	C	36.	A	56.
D	17.	D	37.	B	57.
B	18.	C	38.	D	58.
D	19.	C	39.		
A	20.	B	40.		

Value

PART B: WRITTEN-RESPONSE QUESTIONS

Answer the following questions.

Use the following information to answer questions 1, 2, and 3.

In an experiment, 2 g of baking soda was added to 200 mL of vinegar of various concentrations (c). A gas was produced by the reaction. The rate of the reaction was measured by the length of time the gas was produced (s).

The following table contains the data that was obtained in this experiment.

Relative Concentration (c)	Time of the Reaction (s)
1	110
2	60
3	35
4	20
5	20
6	20

1 1. Name one thing that the person doing the experiment should keep constant.

4 2. In the grid provided, make a graph for the data of this experiment.

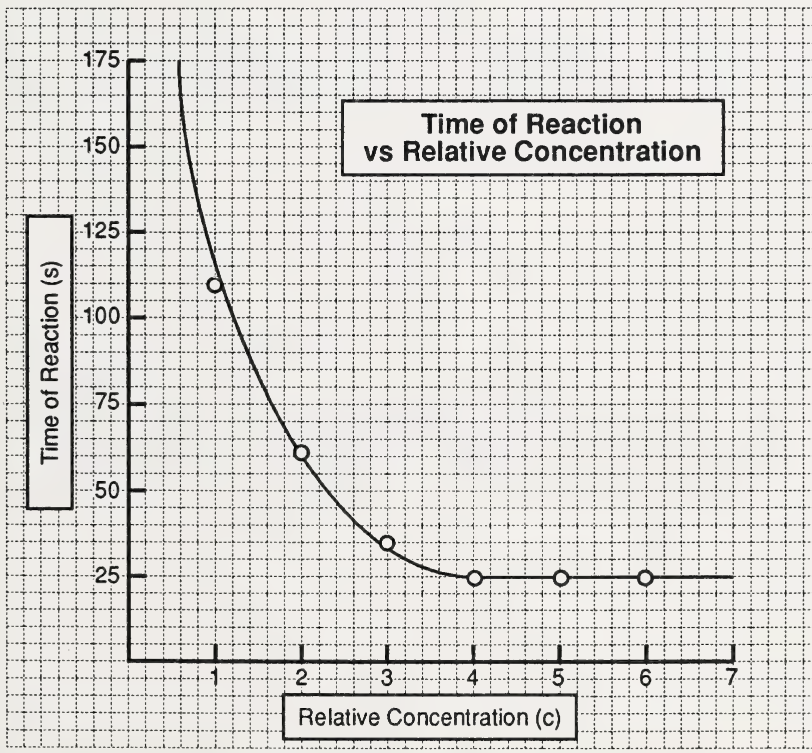
2 3. What is the trend for the reaction rate as the concentration of the vinegar increases?

PART B: RESPONSE PAGE

1. *Students can name any one of the following as having to be constant.*

    - *mass of baking soda used*
    - *volume of vinegar used*
    - *temperature of the vinegar*
    - *amount of stirring of solution*
    - *amount of shaking of solution*

2.



3. *The reaction rate increases as the concentration increases. This continues until a certain concentration is reached. Beyond this concentration (4C), the rate is constant.*

3 4. Give an example of where a valve would be used and describe what its function would be in your example. There are many possible answers. The example should be specific and the function should be clearly described.

3 5. Explain how a hot-air balloon uses heat to float in the air.

5 6. Describe a design for a device to keep an ice cube from melting for as long as possible. Suggest materials and designs to control heat transfer by conduction, convection, and radiation. The device cannot require energy to function.

PART B: RESPONSE PAGE

4. *Answers will vary. The following is a sample response.*

   A valve is used in a football to allow air to easily be put into the ball and to prevent the air from escaping when the ball is not being inflated.

5. *A hot-air balloon operates on the principle of heat causing the air to expand and decrease in density. As the air in the balloon is heated, the average density of the balloon decreases to less than that of the cool surrounding air. This causes the balloon to drift upwards.*

6. *Answers will vary.*

   Example: The container could prevent radiation by having a shiny metal surface covering both the inside and outside of the container. Conduction of heat could be prevented by using styrofoam around all sides of the container. Convection could be prevented by placing a cardboard lid over the entire device.

4 7. A student looking at a simple electric motor wondered why a permanent magnet could not be used for the armature. That way no electricity would be needed. Explain why the armature must be an electromagnet in order to rotate between the poles of the exterior permanent magnet.

3 8. How can you use a compass to detect a current in a wire?

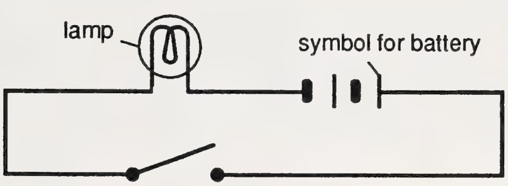
3 9. Suppose you have a 3V battery, a 3V lamp, and connecting wires with alligator clips. Draw a circuit diagram for a simple device that can be used to test whether a material is a good conductor. Also tell how to use the device and tell how it will indicate conductivity.

PART B: RESPONSE PAGE

7. *The answer should include the idea that the armature must be an electromagnet so that its polarity can be reversed with every half turn.*

8. *Pass the wire over or under the compass. The wire shold run in the original direction of the needle. For more sensitive detection, coil the wire around the compass with many turns. A current passing through the wire will cause the needle to deflect. The amount of deflection varies with the current strength.*

9. *The circuit for the device should be as follows:*



The test material is placed across the open part of the circuit. The lamp will not glow if the material is an insulator. If the lamp glows, the material is a conductor. The brightness of the lamp will vary with the conductivity.

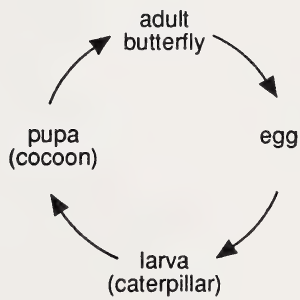
3 10. What does natural selection mean?

6 11. Give an example of metamorphosis and suggest how the different forms of the species are adapted to their special function and/or environment. You may include a diagram in your answer.

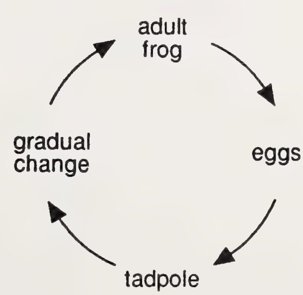
PART B: RESPONSE PAGE

10. *Natural selection means that a population of species in nature can evolve or change over long periods of time. Only organisms with the best variation for survival in the environment will pass on their traits to the next generation. In turn, the new generation will develop their own variations and pass them on to their offspring.*

11. *Students may use any example they are familiar with. The textbook uses the butterfly, but students probably know about the frog as well. They are to mention one adaptation from each form and explain how it might help the organism survive.*



The adult is swift and colourful to find and attract mates. Its mouthparts are adapted for eating plant nectar. The eggs are small, abundant, and usually the same colour as the surface they are laid on. These adaptations insure that some eggs hatch. The larva has mouthparts for chewing leaves and is usually camouflaged. These adaptations help it obtain nutrients for the dormant stage and survive to that stage. The pupa is usually camouflaged and hidden to enable the insect to survive.



The adult frog is adapted to living on land with its lungs and legs. The adult has mouthparts adapted for eating other animals (insects, crabs). The eggs are laid in large numbers in a protected spot to ensure hatching. The tadpole has gills and fins, enabling it to live in water.

5 12. A public hearing is often involved in a decision-making process to deal with an issue. In Modue 6, you prepared for a public hearing to decide if Rapid Steps should upgrade its sewage treatment plant. Indicate what steps were required before the hearing to present the scientific viewpoint.

PART B: RESPONSE PAGE

12. *Scientist had to select sampling sites which included control sites well above the city and several below the city.*

    Measurements were made for turbidity, phosphates, dissolved oxygen, and biological indicators.

Total: ______
100

END OF FINAL TEST

TEACHER'S COPY

SCIENCE 9

FINAL TEST

GENERAL INSTRUCTIONS

YOU HAVE **TWO** HOURS TO COMPLETE THIS TEST. Work quickly through the complete exam, first concentrating on the questions you are sure you know. Then answer the more difficult questions in the time remaining.

TOTAL MARKS: 100

PART A:	Multiple-Choice Questions	58 marks
PART B:	Written-Response Questions	42 marks

Value

PART A: MULTIPLE-CHOICE QUESTIONS

58 All multiple-choice questions must be answered on the Part A Response Page included in your test.

Read each question carefully and decide which of the choices BEST completes the statement or corresponds to your choice. Locate the question number on the Response Page and fill in the space that corresponds to your choice.

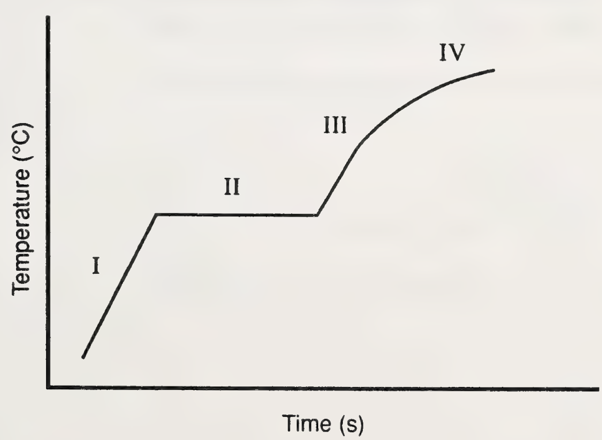
1. If you think that an unknown liquid contains water, which of the following chemicals should you use to check your suspicion?

   A. copper (II) sulphate
   B. cobalt (II) chloride
   C. carbon dioxide
   D. limewater

2. Which of the symbols below indicates that the solution is corrosive?

A. B. C. D.

3. The region on the graph which indicates the melting point of a crystal is



   A. I
   B. II
   C. III
   D. IV

4. When you put 25 g of a solid into 50 mL of warm water, it all dissolved, but when you tried to put an additional 5 g into the water, 3 g that would not dissolve were left. The solubility of the solid is

A. 25 g/100 mL
B. 27 g/100 mL
C. 54 g/100 mL
D. 56 g/100 mL

5. Which of the following is a chemical change?

A. water evaporating
B. salt dissolving
C. wax melting
D. coal burning

6. Placing lead (II) nitrate solution into a flask of potassium iodide solution results in the formation of a(n)

A. liquid
B. element
C. homogeneous mixture
D. precipitate

7. Tomato juice has a pH of 4.2. Human blood has a pH of 7.4. Which of the following is true?

A. Both tomato juice and human blood could be considered neutral.
B. Tomato juice and human blood are both bases.
C. Tomato juice is acidic, human blood is basic.
D. Human blood is acidic, tomato juice is basic.

8. Which of the following is a property of an acid?

A. tastes bitter
B. feels slippery
C. tastes sour
D. turns red litmus paper blue

9. A pH level which indicates a basic substance is

A. 2.7
B. 4.8
C. 7.0
D. 9.4

10. An oxidation reaction has occurred in which of the following examples?

    A. An ice cube disappears in a glass by the sink.
    B. An instant pudding gels in the fridge.
    C. A white powder forms on an old car as the paint fades.
    D. A stain disappears when treated with a powerful cleaner.

11. Which of the following substances is highly compressible?

    A. water
    B. air
    C. vegetable oil
    D. glycerol

12. Liquids and gases are considered fluids because they

    A. have indefinite shape
    B. flow
    C. don't freeze
    D. have small spaces between their particles

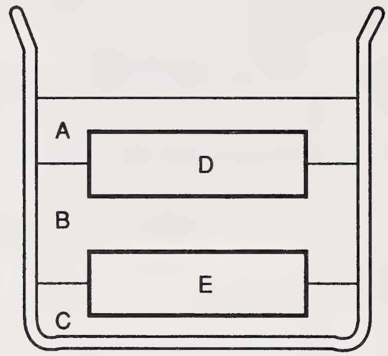
13. It is said that oil is more viscous than water because it

    A. flows more quickly than water
    B. is thinner than water
    C. is more resistant to flow than water
    D. is less resistant to flow than water

14. The best way to make molasses flow more quickly is to

    A. heat it up
    B. cool it down
    C. stir it gently
    D. shake it

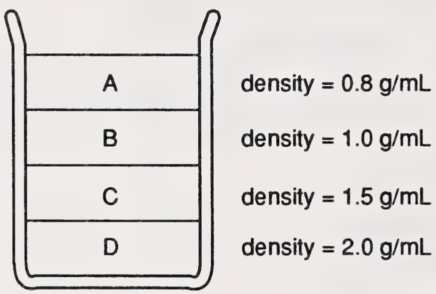
15. Three liquids and two solids are placed in a beaker and are separated as shown in the diagram



Which of the following statements is true?

A. Solid D is more dense than solid E.
B. Liquid B is more dense than solid E.
C. Solid E is more dense than liquid A.
D. Liquid A is more dense than solid D.

16. You put four liquids in a graduated cylinder with densities as listed below.



If an object with a density of 1.2 g/mL is dropped into the cylinder, it will settle

A. on top of liquid A
B. between liquids A and B
C. between liquids B and C
D. between liquids C and D

17. A sample of gold was placed in beakers of oil, mercury, water, and alcohol. It sank to the bottom in each case. Using a copper sample, it sank in all liquids except mercury. Which of the statements is a possible conclusion for this experiment?

A. Alcohol has a density less than water.
B. Oil has a density less than oil.
C. Copper has a density greater than mercury.
D. Gold has a density greater than copper.

18. A reasonable measurement of the air pressure today would be

A. 1000 kPa
B. 100 kPa
C. 1.0 kPa
D. 10 kPa

19. The reason that a block of cement loses weight as it is lowered into water is because

A. it is losing mass
B. it is denser than the water
C. the water is a liquid
D. of the buoyant force of water

20. A hydrometer measures

A. density of liquids
B. displacement of liquids
C. density of solids
D. pressure of liquids

21. The pressure under a liquid depends on

A. the weight and the density of the liquid
B. the depth and volume of the liquid
C. the density and depth of the liquid
D. the mass and density of the liquid

22. The pressure inside a hydraulic press is

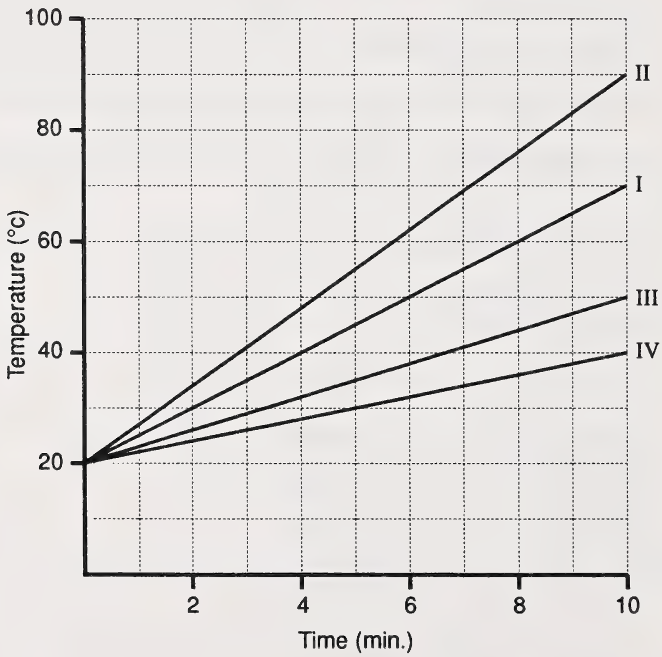
A. higher at the smaller piston
B. higher at the larger piston
C. the same throughout the system
D. lower at the small piston

23. The SI unit for quantity of heat is the

A. degree Celsius
B. Kelvin
C. calorie
D. joule

24. A heater produces 10 J of heat per minute. It is used to heat 100 g samples of four different substances. The results of each heating session are provided in the graph. The substance in the graph which has the highest heat capacity is labelled

A. I
B. II
C. III
D. IV



25. Poor conductors of heat can be used for

A. bottoms on pots and pans
B. handles on cooking utensils
C. radiators
D. reducing friction

26. A substance which is a poor conductor of heat is

A. magnesium
B. wood
C. iron
D. silver

27. Substance A has a temperature of 15°C. Substance B has a temperature of 25°C. If the two substances were brought into close contact, heat would

A. move from Substance A to Substance B
B. move from Substance B to Substance A
C. move in both directions
D. not move in either direction

28. When 10 mL of water at a temperature of 35°C is poured into a beaker containing 100 mL of water at 80°C, the mixture will have a temperature

A. slightly lower than 35°C
B. slightly higher than 35°C
C. slightly lower than 80°C
D. slightly higher than 80°C

29. In a solar water heater, water runs through pipes that are exposed to sunlight. The best material for the pipes would be

A. light in colour and a good insulator
B. light in colour and a good heat conductor
C. dark in colour and a good insulator
D. dark in colour and a good heat conductor

30. The part of a solar heating system that provides a place to keep heat for use at night and when it is cloudy is the

A. heat storage device
B. collector
C. air-water heat exchanger
D. pump

31. Current electricity moves best through

A. plastic
B. copper
C. nichrome
D. rubber

32. A galvanometer is a device that

A. detects electrical current
B. measures the voltage of a battery
C. measures the resistance of a load
D. detects the pressure of the electrical flow

33. Current is measured in

A. amperes
B. volts
C. ohms
D. neutrons

34. The piezoelectric effect demonstrates electrical energy being produced from

A. mechanical energy
B. sound energy
C. light energy
D. chemical energy

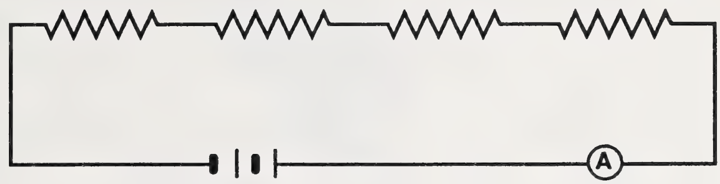
35. Which of the following parts could be used to make a working electrical cell?

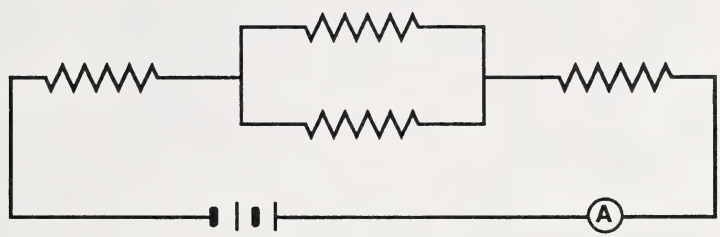
A. zinc and copper electrodes and tap water
B. two zinc electrodes and tap water
C. two copper electrodes and salt water
D. zinc and copper electrodes and salt water

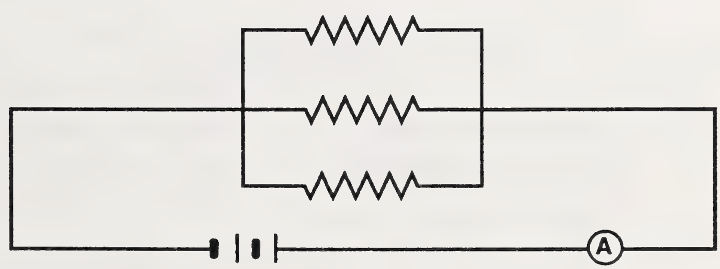
36. A light bulb is connected to a battery. What happens to this light bulb when a second light bulb is hooked in series with it?

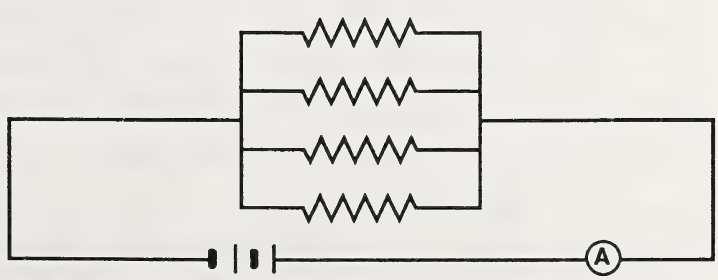
A. The first bulb keeps the same brightness.
B. The first bulb becomes brighter.
C. The first bulb becomes dimmer.
D. The first bulb burns out immediately.

37. In the circuits shown, the resistors have the same resistance and the batteries have the same voltages.





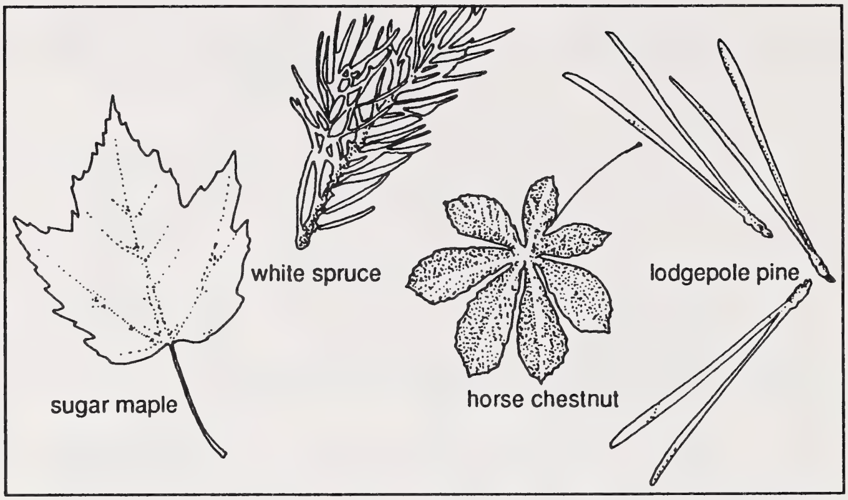




In which circuit will the ammeter reading be the highest?

A. I
B. II
C. III
D. IV

Use the pictures of the leaves and the dichotomous key to answer questions 38, 39, and 40.



Dichotomous Key

#1.	Leaves are needle shaped	go to #2
	Leaves are not needle shaped	go to #5
#2.	Needles attached in bundles	go to #3
	Needles not attached in bundles	go to #4
#3.	Needle leaves are short	Type A
	Needle leaves are long	Type B
#4.	Needle leaves are short	Type C
	Needle leaves are not short	Type D
#5.	Leaves are simple	go to #6
	Leaves are made up of many leaflets	go to #7
#6.	Leaves are notched greatly	Type E
	Leaves are not notched greatly	Type F
#7.	Leaflets extending from the centre	go to #8
	Leaflets not extending from the centre	go to #9
#8.	Leaf consists of three or less leaflets	Type G
	Leaf consists of three or more leaflets	Type H
#9.	Leaf consists of three or less leaflets	Type I
	Leaf consists of three or more leaflets	Type J

38. The horse chestnut leaf could be identified as

A. Type E
B. Type F
C. Type H
D. Type J

39. The white spruce leaf could be identified as

A. Type A
B. Type B
C. Type C
D Type E

40. The sugar maple leaf could be identified as

A. Type C
B. Type F
C. Type G
D. Type I

41. A fish with a mouth that faces upward and that is streamlined for swimming is likely a

A. slow swimming bottom feeder
B. fast swimming bottom feeder
C. slow swimming surface feeder
D. fast swimming surface feeder

42. The Linnaean classification system organizes living things into seven categories. In order from the most general to the most specific, they are

A. Kingdom, class, phylum, order, family, genus, species
B. Species, genus, family, order, phylum, class, kingdom
C. Kingdom, phylum, class, order, family, genus, species
D. species, genus, family, order, class, phylum, kingdom

43. The phylum Arthopoda is made up of animals with

A. tube feet
B. gills for breathing when they are young
C. worm-like bodies
D. exoskeletons and jointed limbs

44. The phylum Gymnosperms include

A. ferns and mosses
B. tulips and oak trees
C. pine trees and apple trees
D. spruce and pine trees

45. The major kingdoms of living things are

A. Prokaryotae, Fungi, Mammalia, Chordata, Plantae
B. Prokaryotae, Plantae, Cnidarians, Animalia, Protists
C. Animalia, Plantae, Fungi, Protista, Monera.
D. Animalia, Plantae, Fungi, Chordata, Protista

46. Termites cannot digest the wood fibers themselves, but inside their bodies lives a microorganism that digests the wood fibers for them. Both animals benefit each other. This is an example of

A. mutualism
B. mimicry
C. camouflage
D. a predator and prey relationship

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A. increased ultraviolet light
B. increased amounts of carbon dioxide emissions
C. evaporation of the world's oceans
D. increased plant growth in northern regions

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B. useless
C. discarded
D. causing pollution

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B. improved medical treatments were developed
C. food production was improved
D. all of the above

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B. economic viewpoint
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B. non-biodegradable
C. abiotic
D. biotic

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B. automobile exhaust contains many particulates
C. industrial processes produce nitrogen oxides as wastes
D. carbon monoxide is produced in major forest fires

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A. suspended solids
B. biodegradable wastes
C. phosphates
D. nitrates

55. Phosphates and nitrates are precipitated out of sewage effluent in the

A. secondary sewage treatment
B. tertiary sewage treatment
C. primary and tertiary treatment
D. secondary and tertiary treatment

56. Water which contains a large variety of invertebrates has an oxygen content which is considered to be

A. excellent
B. good
C. critical
D. low

57. Water which contains a few mayfly larvae, but many midge larvae has an oxygen content which is considered to be

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B. good
C. critical
D. low

58. Mary was checking the water quality of the Bow River. She obtained a partially filled test tube of river water. She added 20 drops of dilute ammonium hydroxide and a few millilitres of magnesium sulphate to the contents of the test tube. A precipitate formed. What pollutant is likely present in the water?

A. sulphuric acid
B. bacteria
C. radioactive wastes
D. phosphates

PART A: RESPONSE PAGE

______	1.	______	21.	______	41.
______	2.	______	22.	______	42.
______	3.	______	23.	______	43.
______	4.	______	24.	______	44.
______	5.	______	25.	______	45.
______	6.	______	26.	______	46.
______	7.	______	27.	______	47.
______	8.	______	28.	______	48.
______	9.	______	29.	______	49.
______	10.	______	30.	______	50.
______	11.	______	31.	______	51.
______	12.	______	32.	______	52.
______	13.	______	33.	______	53.
______	14.	______	34.	______	54.
______	15.	______	35.	______	55.
______	16.	______	36.	______	56.
______	17.	______	37.	______	57.
______	18.	______	38.	______	58.
______	19.	______	39.		
______	20.	______	40.		

Name of Student ______________________ Student I.D. # ______________

Name of School ______________________ Date ______________

Value

PART B: WRITTEN-RESPONSE QUESTIONS

Answer the following questions.

Use the following information to answer questions 1, 2, and 3.

In an experiment, 2 g of baking soda was added to 200 mL of vinegar of various concentrations (c). A gas was produced by the reaction. The rate of the reaction was measured by the length of time the gas was produced (s).

The following table contains the data that was obtained in this experiment.

Relative Concentration (c)	Time of the Reaction (s)
1	110
2	60
3	35
4	20
5	20
6	20

1 1. Name one thing the person doing the experiment should keep constant.

4 2. In the grid provided make a graph for the data of this experiment.

2 3. What is the trend for the reaction rate as the concentration of the vinegar increases?

PART B: RESPONSE PAGE

1. ____

2.

3. ____

Name of Student ____________________ Student I.D. # ________________

Name of School ____________________ Date ________________

3 4. Give an example of where a valve would be used and describe what its function would be in your example. There are many possible answers. The example should be specific and the function should be clearly described.

3 5. Explain how a hot-air balloon uses heat to float in the air.

5 6. Describe a design for a device to keep an ice cube from melting for as long as possible. Suggest materials and designs to control heat transfer by conduction, convection, and radiation. The device cannot require energy to function.

PART B: RESPONSE PAGE

4. ______________________________

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5. ______________________________

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6. ______________________________

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Name of Student ____________________ Student I.D. # ____________________

Name of School ____________________ Date ____________________

4 7. A student looking at a simple electric motor wondered why a permanent magnet could not be used for the armature. That way no electricity would be needed. Explain why the armature must be an electromagnet in order to rotate between the poles of the exterior permanent magnet.

3 8. How can you use a compass to detect a current in a wire?

3 9. Suppose you have a 3V battery, a 3V lamp, and connecting wires with alligator clips. Draw a circuit diagram for a simple device that can be used to test whether a material is a good conductor. Also tell how to use the device and tell how it will indicate conductivity.

PART B: RESPONSE PAGE

7. ____

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Name of Student ____________________ Student I.D. # ____________________

Name of School ____________________ Date ____________________

3 10. What does natural selection mean?

6 11. Give an example of metamorphosis and suggest how the different forms of the species are adapted to their special function and/or environment. You may include a diagram in your answer.

PART B: RESPONSE PAGE

10. ______________________________

11. ______________________________

Name of Student ______________ Student I.D. # ______________

Name of School ______________ Date ______________

5

12. A public hearing is often involved in a decision-making process to deal with an issue. In Module 6, you prepared for a public hearing to decide if Rapid Steps should upgrade its sewage treatment plant. Indicate what steps were required before the hearing to present the scientific viewpoint.

PART B: RESPONSE PAGE

12. ______________________________

Total: ______
100

END OF FINAL TEST

Name of Student ______________________ Student I.D. # ______________________

Name of School ______________________ Date ______________________

This is a course designed in a new distance-learning format, so we are interested in your responses. Your constructive comments will be greatly appreciated so that a future revision may incorporate any necessary improvements.

TEACHER QUESTIONNAIRE FOR ______________

Teacher's Name ____________________ Area of Expertise ____________________

School Name ____________________ Date ____________________

Design

1. The modules follow a definite systematic design. Did you find it easy to follow?

   ❑ Yes ❑ No If no, explain.

   ____

   ____

2. Did your observations reveal that the students found the design easy to follow?

   ❑ Yes ❑ No If no, explain.

   ____

   ____

3. Did you find the Learning Facilitator's Manual helpful?

   ❑ Yes ❑ No If no, explain.

   ____

   ____

4. Part of the design involves stating the objectives in student terms. Do you feel this helped the students understand what they were going to learn?

   ❑ Yes ❑ No If no, explain.

   ____

   ____

5. The questions in the Module Booklet are to help clarify and reinforce the instructional materials. The answers were placed in the Learning Facilitator's Manual. Did this design prove helpful?

☐ Yes ☐ No If no, explain.

---

6. Did the Follow-Up Activities prove to be helpful?

☐ Yes ☐ No If no, explain.

---

7. Were students motivated to try these Follow-Up Activities?

☐ Yes ☐ No If no, give details.

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8. Suggestions for computer and video activities are included in the course. Were your students able to use these activities?

☐ Yes ☐ No Comment on the lines below.

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9. Were the assignments appropriate?

☐ Yes ☐ No If no, give details.

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10. Did you fax assignments?

☐ Yes ☐ No

11. If you did fax, did you get satisfactory results from using this procedure?

❑ Yes ❑ No If no, give details.

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Instruction

1. Did you find the instruction clear?

❑ Yes ❑ No If no, give details.

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2. Did your observations reveal that the students found the instruction interesting?

❑ Yes ❑ No If no, give details.

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3. Did you find the instruction adequate?

❑ Yes ❑ No If no, give details.

___

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4. Was the reading level appropriate?

❑ Yes ❑ No If no, give details.

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5. Was the workload adequate?

❑ Yes ❑ No If no, give details.

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6. Was the content accurate and current?

❑ Yes ❑ No If no, give details.

7. Did the content flow consistently and logically?

❑ Yes ❑ No If no, give details.

8 Was the transition between booklets smooth?

❑ Yes ❑ No If no, give details.

9. Was the transition between print and media smooth?

❑ Yes ❑ No If no, give details.

Additional Comments

When you have completed this questionnaire, please mail it to the following address:

Design Department
Alberta Distance Learning Centre
Box 4000
Barrhead, Alberta
T0G 2P0

Science 9

9SC09T10

L.R.D.C.
Producer

FIRST EDITION
1992